Electric Locking

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PREFACE

THE modern necessity for speed, for heavier and longer trains, and the demand of the public for greater facilities, both freight and passenger, have increased the complexity of railroad operation, resulting in increased difficulties for signal engineers in providing immunity from accidents. For this reason the tendency in modern signaling practice has been to secure increased safety by decreasing the human element as a vital factor and substituting the more dependable automatic operation of devices—Electric Locking. So little information is to be had on this important subject that it is hoped many railroad men will find this book of value.

J. A.

Cleveland, Ohio,
November 30, 1917.

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PRELIMINARY CONSIDERATIONS

Inception of Electric Locking. In the early days of railway signaling, when interlockings were not universally adopted as a means of controlling switches and signals, the switches were thrown by operating levers mounted near them, and the operator, being close to the function operated and, after having given his hand signal for the train to proceed, was able to watch the movement of the passing train, so there was no danger of his inadvertently throwing a switch under a moving train or in the face of an approaching train to which a hand signal had already been given. The advantage of concentrating the switches as much as possible, so that they could be worked from a central point, soon became evident, as they could thereby be protected by a much smaller number of signals than would be necessary if a signal were placed for every switch. Also increased traffic and the consequent necessity for facilitating the handling of trains at certain congested points made it urgent to substitute for the old cumbersome method of throwing the switches a more convenient arrangement. Thus the levers for controlling the switches in a given locality were assembled in a common frame, suitably interlocked and mounted in a tower at a distance from most of the switches, so that they could all be operated from a central point. When at this time fixed signals were adopted, and also operated from such central points to give information to the engineman, instead of the formerly employed hand signals, it became necessary to devise some means not only for the purpose of indicating to the leverman that the unit had responded to a given lever movement and that the switch or signal being operated had fully and completely performed the movement intended, but also make the movement of the trains immune from dangers caused by errors on the part of the operator. This was the advent of mechanical interlocking machines; and so far as to prevent the display of clear signals being given simultaneously over conflicting routes or for the clearing of a signal not yet prepared to receive a train, it proved very satisfactory. Notwithstanding this vast improvement experience soon taught that the errors committed on the part of the leverman through carelessness, rapid manipulation of the levers, negligence or hasty action, were numerous.

In order to make the movement of trains through an interlocking plant perfectly safe it has been deemed necessary to impose certain restrictions upon the leverman and partly relieve him of the responsibilities incidental to the safe handling of trains approaching and passing through an interlocking plant; in other words, means which would not only insure the operators being more deliberate in their actions, but also make them respect rules which, under ordinary working conditions, would be disregarded and eventually result in disaster. To accomplish this, various means have been devised—some purely mechanical, others electro-mechanical. For the control of the latter devices, numerous different circuit schemes have been developed to suit existing conditions. The means adopted are all automatically controlled, which again follows the tendency of modern signaling practice in securing increased safety by decreasing the human element as a vital factor and substituting the more dependable automatic control of devices.

Classification of Electric Locking. The various schemes for the supplementary protection of an interlocking plant (partly exclusive of the mechanical locking in the interlocking machine and often in conjunction with it) can be classed under one general head of ELECTRIC LOCKING.

The Railway Signal Association manual defines electric locking as being "The combination of one or more electric locks and controlling circuits by means of which levers of an interlocking machine, or switches or other devices operated in connection with signaling and interlocking, are secured against operation under certain conditions."

It may be classified as follows: Indication locking, section locking, route locking, stick locking, approach locking and sectional route locking. These classes are what may be termed essentials of electric locking. Additional special locking features are frequently desired or required by the peculiarities of local conditions or arrangements of the interlocking facilities. The most important of these auxiliary electric locking features are check locking, bridge locking and outlying switch locking, each providing the particular protection that their nomenclatures imply.

Evolution of Electric Locking. Without attempting to go

into the history of electric locking, a few words will be said with regard to the development of these different classes of electric locking.

In an interlocking machine the levers are so interconnected that a route must be set up properly before a signal can be cleared and after it is cleared the route cannot be changed unless the signal is again restored to the stop position. But with ordinary interlocking it is possible after having restored the signal normal to change a switch ahead of a train or throw it under a train and afterwards clear a conflicting signal. This led to the introduction of the detector bar, for switch protection, but, as it was considered an unsatisfactory protective medium by many signal men (see Chapter IV), it was partially superseded, particularly at large plants, by electric switch locking, which prevented a switch from being thrown under a train by the train shunting the track circuit and locking the lever so it could not be moved. This was the advent of the track circuit and the "Section Locking." Afterwards this locking was extended to fouling points on the track and also to take care of switches in advance of the switch over which the train was moving.

With this protection on all switches, if a leverman put his signal normal the switches were still locked up until the train had passed over them. This constituted what is termed "Route Locking." At busy terminals this protection proved satisfactory from a safety standpoint, but from an operating point of view, it did not admit of expeditious handling of traffic. Hence the electric switch locking was arranged to release, as soon as a train had passed, a switch and permit the locking to take effect in whichever direction the train was running. "Sectional Route Locking" is the term applied to this class of electric locking.

Although precautions in locking and handling of trains were observed, as just stated, practice soon proved that where high speed of trains was indulged in no dependence could safely be placed on the leverman, and it was found to be necessary to adopt means to prevent a leverman from careless or premeditated changes of route once given and accepted by an engineman. Thus the locking was so arranged that when a train entered a track circuit, 3,000 ft. or 4,000 ft. from the distant signal, or as soon as a distant or home signal was cleared, it locked the levers so that the signal could be placed normal, but the route could not be

changed until the train had passed the home signal. This was termed "Approach Locking" or "Stick Locking."

With the advent of power-operated signals and power interlockings, it became necessary to add another safety feature, namely, "Indication Locking," which would insure the correspondence of the position of the function and the lever. Where tracks uniting two interlocking plants cease to be adequate for the needs of traffic between them when the use of each track is restricted to train movements in one direction only, "check locking" is employed. This provides electric locking between towers by the signals in one interlocking being inter-controlled with those of another when the signals govern opposing train movements over tracks common to both. Where a switch is located close to an interlocking, but too far away from the tower to be operated from the interlocking machine, protection is provided by electrically locking the switch so that it cannot be moved without the knowledge and consent of the leverman. This is called "outlying switch locking." A drawbridge or other type of operating bridge is generally provided with locking so that the bridge is locked in its closed position and so interlocked with the signals approaching the bridge that they cannot be cleared unless the bridge is in the proper position and, consequently, constitute "bridge locking."

Locking Circuit Design. Electric locking circuits admit of innumerable variations and nearly every installation requires some special schemes of inter-connections and new designs, which often radically differ from the standard practice of the particular road for which the protection is contemplated. There are, however, certain generic features adhered to, which obtain in most cases and which form a basis for the more complicated circuits designed to meet complex situations. It is their differentiation which often produces the seeming complexity, when a circuit is viewed as a whole. It is therefore the intention to present first each style of locking in its basic form and also the more simple application of the different styles of electric locking as classified by the Railway Signal Association, then present their modifications and finally the various styles combined, to suit more complex situations. It will be found that very seldom is only one style of electric locking applied to a plant, as in most cases a

combination of different styles is found best adapted to needs.

Many differences exist in the art and practice of signaling of railroads and there are naturally minor points of superiority in the methods of safeguarding trains in all systems. A designer of electric locking circuits should therefore not only give careful attention to the minutest details of the circuit itself, but should also obtain intimate knowledge of the workings of the signal appliances involved in order to properly know how a dangerous condition is most liable to occur, and thereby add features in the locking circuit which will guard against them. While provisions must be made for the normal condition of affairs, the dangers incident to exceptional circumstances must be met by exceptional precautions. The possible dangerous conditions that seldom happen are the ones that prove most fatal when they do occur, and no interlocking plant can be considered perfectly safe except with all such contingencies anticipated and all probable dangers averted. For instance, the failures at danger for a signal indication can only wrongly delay a train and cause an unnecessary stop; but failures at clear, by giving the engineer a proceed indication when such may not be safe, are the only ones that can really be called dangerous. It should be remembered, however, that the saving of an unnecessary stop also means a saving of money, and while, as just stated, a clear signal failure is the only dangerous derangement of a signal system, the danger failure should also receive due consideration when making provisions for safeguarding train movements. The governing principle in electric locking, as well as in all other branches of signaling, should be:— a failure of any part of the apparatus or circuits should always be on the side of safety.

What Class to Apply. While it is evident that electric locking is necessary to employ as an adjunct to interlockings, the question of what type to apply to interlockings of various types and sizes is generally one of individual opinion of the signaling officials for the road where the protection is to be applied and, to some degree, will also depend upon the complexity of the track layout, the traffic facilities desired, the economical aspects and the protection required. The usual practice, of course, has been to increase the amount of protection applied in proportion to the size and the importance of the interlocking plant. Thus, at large

and congested yards, terminals and busy grade crossings, the most elaborate arrangements of electric locking protection are usually installed. Smaller plants are generally provided with electric locking protection of a less complicated nature, and often with quite primitive apparatus, which appears crude when compared with modern appliances. This, of course, seems very logical, although the wisdom of so doing, when considered from various viewpoints, is sometimes questionable. For instance, at busy plants the levermen have no time for anything else but attending to the manipulation of levers, and by constant practice they become extremely proficient, and experience has proven that mistakes are rarely made. An error once committed on the part of the leverman, however, might prove a serious matter, and the expense therefore of auxiliary apparatus and intricate circuits, providing all protection possible, is justified. On the other hand, a leverman at a small, isolated interlocking plant on a branch line of light traffic, has an excessive amount of time on his hands between trains. Being far removed from any supervising authority and the plant probably not being as perfectly maintained, nor as repeatedly inspected as the main line plants, he is left most of the time to his own resources. As it is human nature to experiment with machinery, so it is perfectly natural for these men to try all kinds of experiments with the signaling appliances, probably to discover flaws or in some way to beat the combination. At night there are also usually few trains and nothing to keep the leverman's mind off sleep. If he should happen to go to sleep and a train suddenly shows up there is a great possibility of his so manipulating the levers as to cause a derailment. It would therefore seem just as important to equip these plants with most auxiliary safety devices commonly found at the more important plants, provided, of course, that the management finds such additional expenditures warranted.

Apparatus Used in Electric Locking. In connection with electric locking there are various kinds of accessory apparatus which are referred to throughout the chapters to follow, and which may need some description as to their function, control and operation when applied in connection with electric locking.

Track Instrument. A track instrument is used in places

where conditions will not permit the use of a track circuit, and it will either effect the locking or the release of the locking of a plant. It is adopted for use by roads not employing track circuits, or at isolated places where the maintenance of a track circuit would be prohibitory, or at electric railroads using the rails as a return for the propulsion current.

INTERLOCKING RELAY. An interlocking relay is used on single track roads where the current of the traffic is in both directions and where a certain operation is desired to take effect only with the train running in one direction. It is also used on double track roads at crossings where the density of traffic requires some means whereby a release of the route locking may be accomplished as soon as a train has passed over the crossing, but is still within the limits of the interlocking. There are, broadly speaking, two types of interlocking relays, and under ordinary conditions either type will answer the purpose for which it is designed There are circuit arrangements, however, which necessitate the use of a type of an interlocking relay which, in addition to its regular interlocking features, also contains certain distinct features not embodied in the other types. This feature, which is the employment of the interlocking parts as a part of the circuit controlled by the relay, while it may not be recommended as a good design on account of lightning trouble, etc., is in many cases an essential requirement.

Fig. 1 shows diagrammatically an example of the method by which the interlocking features are accomplished in a relay when the interlocking parts are not used as a part of the circuit to be controlled. "A," "B," "C" and "D" show, respectively, the position of the armatures and interlocking parts with the train located on different parts of the track circuit. It will be noted that there is no electrical connection between the interlocking arms or the contact arms, so that a circuit can only be completed between points 1 and 2 and between 3 and 4.

Fig. 2 shows in diagrammatic form the operation of an interlocking relay that has the interlocking parts utilized for the control circuit. As the contact arms are also used for interlocking purposes, with the relay in a position as shown in diagram "D," a circuit will be completed from 1 to 2 through the contact arms. This is the feature which makes it possible to arrange a circuit

so that a train entering one track section on one side of a grade crossing will effect the locking of a route and the train entering the section section will effect the release of the locking.

While the R. S. A. has adopted a standard symbol for inter-

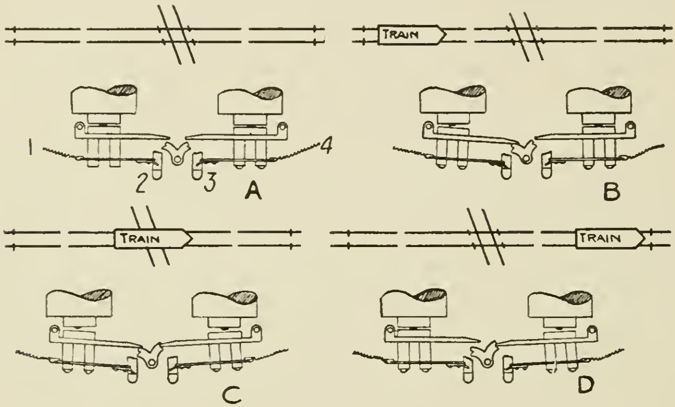


FIG. 1.

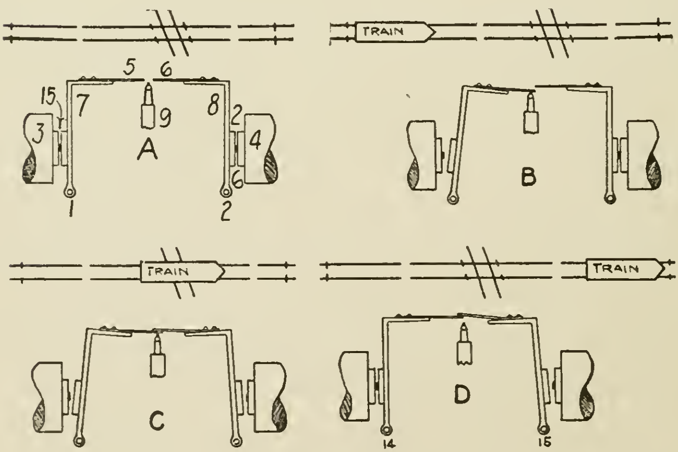


FIG. 2.

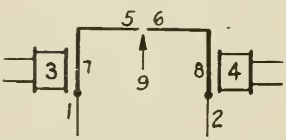


FIG. 3.

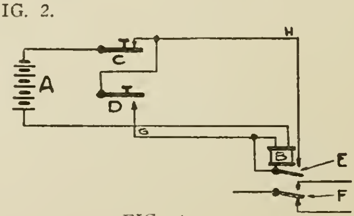


FIG. 4.

locking relays, this symbol cannot represent both types of the relays just described. Thus Fig. 3 should be used as the symbol for the last described type of an interlocking relay.

Stick Relays. A stick relay is used when it is desired to prevent certain operations to take place until other operations or conditions are fulfilled. It is employed to a great extent in electric locking, sometimes as a track relay, but more often as a line relay. It may be said to be one of the most employed mediums in electric locking and can be used to advantage in any of the different styles.

It is a relay whose controlling circuit is so arranged that one of its own front contacts closes a path for the current through its own coils. A stick relay may be so connected into a circuit that its normal position may be either energized or de-energized. A normally open stick relay scheme is shown in Fig. 4. "C" and "D" represent push buttons, but may in practical use be substituted with either relay contacts, slow release contacts, floor push contacts, signal circuit controllers, lever contacts, contacts on a track instrument or a pair of car wheels and axle. It will be noted that with the closing of the contact "D" the stick relay "B" will become energized through contact "C," wire "G" and its own coils. An immediate break of contact "D" will not affect the position of the relay, which will remain energized, being held through contact "C," wire "H," its own coils and its own front point "E." The breaking of contact "C," however, will immediately release the stick circuit and cause the relay to drop. In order to again pick up the relay, the same operation must take place, that is, contacts "C" and "D" must be made, while the release of the armature is caused by the breaking of contact "C" only. Thus a stick relay circuit will always have some *controlling contacts* which, in the present case, is switch "C." The energization of the relay depends entirely upon this contact. A stick relay circuit has also a *pick up contact* "D" and a pick up wire "G"; "H" is generally called the stick up wire and "E" the stick point. Contacts "F" are to be used for circuits controlled by the stick relay. The circuits for a normally energized stick relay will be the same, excepting that the successive steps in the operation will be the reverse of the normally de-energized scheme.

The question of the employment of the normally de-energized

or normally energized stick relay often puzzles a novice in circuit work, and it may be stated here that the control of anything electrically by an open circuit is unreliable for many reasons well understood by up-to-date circuit men. In using an open circuit the electric current is only called into action when the work must be done, with no assurance that it will perform the work or produce the desired result.

Tower Indicators. In connection with most classes of electric locking it is desirable that means be provided to convey information to the leverman with regard to the operation of signaling apparatus or the approach of trains. Tower indicators are the general term applied to such indication devices that are designed for use in interlocking towers. The necessity for employing auxiliary devices of this type is often due to local conditions such as the presence of buildings, trees and bridges, or curves and grades in the track. Adverse weather conditions also often prevent the leverman from properly observing the movement of trains. Due to the location of a signal, it is often impossible for the leverman to note its operation and at night, where back lights on signals are not provided, no check is had upon the operation of the apparatus without the employment of indicators. An indicator employed to show the presence of a train on a certain length of track is termed a track indicator or track repeater. An indicator employed to signify the approach of a train to the interlocking is called an approach indicator; and one that indicates the position of a signal, a signal repeater.

Indicators arranged as signal repeaters generally have a movable miniature semaphore arm which is shaped and assumes a position similar to that of the signal by which it is controlled. An indicator of this type is designed to give indication in two or three positions.

Indicators arranged for approach indication are generally of the disk type and known as the disappearing disk type of an indicator. Track indicators should be of a distinctly different type than the others. A type like the revolving disk or one whose movable and visible parts are designed in the form of a dumb-bell is recommended.

Where it is necessary to distinguish between two or more indicators, a designating number or letter is painted either on the

outer face plate or the front of the cover. The former method may be considered preferable, since the covers of instruments mounted side by side might accidentally become interchanged. The designation given an indicator might be the number of the signal with a prefix designating the type or the track section to which the instrument is connected, or any other method of designation adopted.

Tower indicators are generally arranged with contact fingers to be used for the control of circuits. Many railroads object to the employment of these contacts for circuits, as they consider the operation and adjustments obtainable with tower indicators, due to the many movable parts, too unreliable for the actuation of important circuits. The indicators, therefore, merely act as repeaters for relays, the relays being used for the make and break of electrical contacts.

Illuminated Track Indicators. The use of separate indicators to repeat the condition of the various track circuit sections has in many up-to-date installations given way to illuminated track diagrams, which undoubtedly give to the leverman better information as to the movement of trains over the interlocking than that given by separate indicators. Illuminated track indicators have the track layout painted on ground glass and show whether or not a track section is occupied, by electric lamps placed behind the glass, the lamps being controlled by the track circuit. These types of indicators are usually more expensive to maintain than other types on account of the comparatively large amount of current constantly used. Where the track arrangement is very complex and a large number of track circuits necessary, separate indicators of the semaphore or a similar type, one for each track circuit, is somewhat confusing, as it is necessary for the leverman to always keep in mind to which circuit each one is connected. With illuminated track indicators the necessary information about each track section is given, even when trains are not visible to the leverman. In addition, all functions are numbered on the diagram, thus making it serve two purposes and eliminating the necessity for a separate track diagram.

Another effective visual indication is to install a light at each switch lever in the interlocking machine and so arrange the control through the route or other electric locking relays that a

visual indication is obtained showing whether or not the lever may be manipulated. Often both illuminated track diagrams and lever lights are installed at one plant, thereby giving the leverman two visual indications as to the occupancy of tracks. This method of conveying information to the leverman is particularly desirable where sectional route locking is employed, as the movement of a train and the consequent release of the electric locking can be watched during any train movement over the plant. In place of signal repeaters lever lights are often used and the control so arranged that the lights will burn when the signal is clear.

Annunciators. In addition to the visual indication provided by approach indicators, annunciators are employed to give an audible indication that a train has passed a certain point when approaching an interlocking plant. These will call the leverman's attention to the condition they indicate when he is otherwise occupied. They are not only necessary at congested points, but also at places where the distance of an approaching train from the interlocking cannot be gauged with a sufficient degree of accuracy to avoid delays either to the approaching train or to other trains whose movements are dependent upon it. Electric bells or buzzers are usually employed as audible annunciators.

It is often desirable, particularly where no visual indicators are employed, to use bells or buzzers having different tones for different tracks in order to avoid confusion if more than one train should approach an interlocking simultaneously. Bells with different forms of gongs, giving a variety of tones, are known as the dome, tea, cow and sleigh bell types. Single stroke and vibrating types of bells are also often employed as two distinctive types.

Screw Releases. This is the general term for manually operated instruments which require a given length of time to complete their movement, the operation being performed by the leverman. These instruments are known by numerous different names, as slow releases, time releases, electric hand time releases, electro mechanical hand time releases, and mechanical hand time releases. They are all functioned to accomplish the same thing, and that is to release the electric locking in an interlocking machine which, because being out of order or for some other abnor-

mal condition such as an error on the part of the leverman, holds locked a lever which it is desirable to move in order to avoid delaying a train. To prevent hasty action by a disturbed or excited leverman the releases are so constructed that they can be operated only by turning a screw a certain predetermined number of times. The release must always be returned to its original position before the plant is again restored to normal operating conditions and to the control of the leverman. This is necessary, for when the electric locking is released by the leverman in an emergency, conditions must be made such that the interlocking plant cannot be used until the releasing device has been placed normal, otherwise there would be nothing to prevent the operator from maintaining the release in the reverse position and thus keeping the electric locking ineffective.

The screw release has two positions: the normal position which it occupies when nothing is operated, and the reverse position which it occupies during its movement. In the *electric screw releases* the turning of the handle and the consequent movement of the operating parts will break contacts controlling electric circuits, and when the release is fully reversed will make contacts for other circuits. In *electro-mechanical screw releases* the turning of the handle not only causes the make and break of contacts controlling electric circuits, but in addition thereto, being located on the locking bed of the interlocking machine, it will lock one or more levers in a certain position until it is again put normal. A *mechanical* screw release effects the release of a lock by mechanical means only, in that the reversal of the screw release raises one lock armature by a lifting dog operated by the release, while at the same time certain levers in the interlocking machine are locked by dogs attached to the bar operated by the screw release, in this way insuring that the release is placed normal before other routes can be set up.

The time required to operate the screw release generally varies in length from ten seconds to ten minutes, the adjustment in the length of time depending upon local conditions. The time interval element in a screw release should receive careful consideration and the length of time required in the release of the locking for one plant may not be suitable for another. If the traffic at a plant is very heavy, the time limit would necessarily have to be short so that no long delays in train movements will be experi-

enced, and if traffic is light the time limit may be made as long as two or three minutes. Another item enters into the time interval element, and that is the minimum breaking distance of the trains at the plant. If an engineman consumes as long as three minutes between the distant and the home signals it is evident that he can stop in this distance in three minutes should the distant and the home be put to stop against him. In other words, the time should be so adjusted that it will not be possible for the operator to put a distant or home signal to stop that has already been accepted by the engineman, then operate his screw release, thereby releasing the route and next open a derail in the face of the train. Thus the time required to operate the screw release should be long enough to permit a train to come to a stop after a signal has been taken away from it, before it is possible for the operator to change the route.

Screw releases may be substituted with hand switches or knife switches, but these must be placed downstairs in the tower or at a distance from the operator, so that it will take him some time to reach it in order to give the requisite time (as with a screw release) before one route is released and another set up. This type of a release was very common in the early days of signaling, and when used in present practice generally is placed in a box with glass front.

Emergency Switch. In addition to the screw release, which in most cases is employed only to release the route locking while still maintaining the other parts of the protection combined with the route locking, an emergency switch is often introduced to take care of any failures either in the track circuit, stick relay circuit or local battery troubles. The emergency switch is generally enclosed in a locked case with glass cover and placed downstairs in the tower. Thus, in the event of trouble, the towerman is compelled to go downstairs, break the glass of the box and throw the switch, after which he will operate his screw release or other releasing device. As in the case of screw releases, the circuit through the emergency switch is arranged so that it must be placed normal before the plant is restored to normal operating condition. A snap switch is often employed as an emergency switch. With this a quick motion is possible when placed from one position to another by the operation of a spring.

Time Release. A time release is frequently employed for the release of an electric lock or other circuits used in connection with the lock circuit when a time interval is required for the release; but where it is undesirable to have the operator manipulate the instrument during the entire time interval. This gives the operator an opportunity to perform his other duties while the release is doing its own manipulating after having been started in its action by the operator.

There are several different kinds of time releases, including the mercury, clock work, electric and thermostatic, all operated as indicated by their names. They will make or break a circuit any predetermined number of seconds or minutes after it has been put in action. It may be put in action either automatically, when it is attached to a lever, where the placing of the lever in a certain position will cause its operation; or manually, when the operator by the turning of a knob or the closing of a circuit puts it in action. The maximum time interval which can be secured with a time release is ten minutes. Automatic recording devices as counters are often installed on releases and the records carefully checked to insure strict adherence to prescribed rules and as a check upon the errors committed by various levermen.

Other Release Schemes. On some railroads the release of the electric locking for emergency purposes is accomplished by sealing the lock itself with a car seal or similar device instead of the use of a time release. Then if there is a real need of releasing the locking the leverman can break the seal, open and pick the lever lock and manipulate the lever. When this is done the leverman and maintainer are jointly held responsible for anything that may happen. The seals, sealing iron, etc., must only be in the possession of a responsible person and not the leverman. This scheme is not to be recommended because of the likelihood of a simple mistake on the part of the leverman making necessary the exposure of the lock to further manipulation of levers without any restriction or check until again sealed up.

Mechanical Time Lock. A mechanical time lock is employed in connection with the locking in an interlocking machine and is used in lieu of electric locking circuit. It will introduce a time element between the placing of the signal or other lever

normal and prevent any change in the route governed by the signal upon whose lever it is placed until released by the mechanical time lock.

FLOOR PUSHES. A floor push is used when a momentary electric contact is desired to pick up an electric lock, a stick relay or any other electric device. They are particularly adapted for the control of lever locks not having circuit controllers attached to them. They are fixed in the floor where the signalman can conveniently close the circuit by pressing downward on a button with his foot. A push button, hand switch or table button is frequently used in place of a floor push. The employment of the floor push, however, is more advantageous, as it leaves the operator free to use his hands for other work, as, for instance, the manipulation of a lever in the interlocking machine. A knife switch cannot be used as a substitute for a floor push because the operator is liable to leave the switch in the closed position and permanently maintain a closed circuit through the lock coils, which the switch was installed to prevent.

LEVER LOCKS. An electric lever lock is a device which locks the levers of an interlocking machine to prevent its movement until it is released by an electro-magnet. It consists of either a solenoid with a movable core or plunger, or a vertical or horizontal magnet with an armature. The locking parts consist of a sliding bar or a locking segment that moves in unison with the lever to which it is attached. An electric lock may be placed on a switch, derail, facing point lock, movable point frog, signal, route, master, check lock, bridge lock, rail lock or an outlying switch lock lever. It may lock any of these levers in either one of various positions, or two of them in combination. An electric lock arranged to hold a lever locked in its full normal position is termed a normal lock; one holding it locked in the full reverse position a reverse lock; one holding it locked in the full normal and full reverse position a normal and reverse lock; one holding the lever locked in the understroke position, so that it is possible to reverse the lever, but not possible to place it full normal, is called a half reverse lock; one holding the lever locked in the understroke position, so that it is possible to place a lever full normal, but not possible to fully reverse it, is called a half normal

lock; and one which permits the lever to be moved between the normal and reverse indication or latching positions, but not fully normal nor fully reversed, is called an indication lock. A combination of the full normal and half reverse lock is frequently used.

Where a lever is to be locked in two positions the notches cut must, of course, be far enough apart so as to have sufficient metal between them for the necessary mechanical strength. There are cases where it is necessary to employ two locks on account of this consideration, each lock employed for the locking of the lever in one position. Fig. 5 shows the symbols for the various types

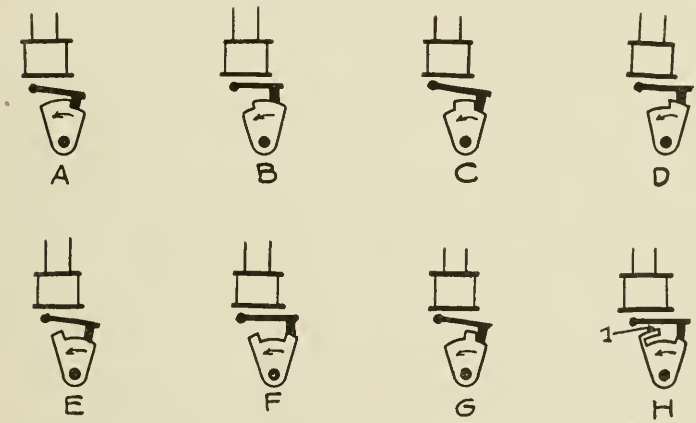


FIG. 5.

of electric locks. "A" is a normal lock, "B" a reverse lock, "C" a normal and reverse lock, "D" a half reverse lock, "E" a half normal lock, "F" an indication lock and "G" a normal and half reverse lock. Where a lock is arranged to lock a lever in one position only it is possible to make arrangements so that the dropping of the lock armature with each operation of the lever is assured. For example, in Fig. 5-H, which shows a half reverse lever lock, a detector 1 is attached to insure that the lock armature is not permanently picked up due to residual magnetism. Should it happen to stick up, the lever cannot be reversed owing to the lock extension striking the detector 1. This type of a segment is very desirable to use whenever possible, as it acts as a check with each manipulation of a lever.

On interlocking machines having what is called lever locking, the lever lock is arranged to lock the lever in either its full nor-

mal or reverse positions. Interlocking machines having what is termed latch locking must have the electric lock arranged to engage with the locking in its operating connection in such a manner that the locking is held in a position which prevents the latch from being moved. A lever lock magnet with the lever in the extreme normal and reverse positions should always be de-energized by so arranging the control circuit that only during its actual use (that is, while the lever is being manipulated) must current flow through it. The reason for this is partly to effect a saving in current consumption, but principally to protect the lock magnet from residual magnetism, which will have a tendency to retain the lock armature in a picked up position. Hence, where a normal or reverse lever lock on a mechanical interlocking machine is controlled by contacts operated by the lever upon which it is placed, the notch in the lock segment is so cut as to permit a slight preliminary movement of the latch or lever, enough to close the lever lock circuit. Such close adjustments, however, are often difficult to maintain, as experience has taught that with a slight amount of lost motion in the many parts between the latch handle and the lever lock, it has happened that the latch shoe has gotten to the top of the rocker before the lever lock has taken effect. Many railroads, therefore, employ a floor push for normal and reverse locks on a mechanical interlocking machine.

Cross Protection. Cross protection is one of the vital factors to be considered in circuit designing and one which enters conspicuously as a safety factor when arranging circuits for indication or electric locking purposes. Cross protection is provided to take care of "crosses," and "crosses" in signaling are the accidental contact of conducting wires, causing either an increased current in a wire or reversing its polarity or energizing a wire which should be dead, and thereby producing a derangement of apparatus. The employment of low voltage apparatus, which is the practice in electric locking, makes extra precautions necessary to prevent improper movements of the apparatus as a result of crosses on account of their being sensitive to outside influences.

A few rules will, better than any description, give a correct conception of the necessary precautions to be taken with the design of locking circuits to insure that the circuits provide adequate cross-protection for the apparatus controlled.

Rule 1:—Controlling circuits should always be so arranged that a cross will cause a signal to indicate stop, a switch to remain in the position which corresponds with the position of the lever, an electric locking device to maintain its locked position and to remain so until the fault is corrected.

When considering the cross protection of devices used for electric locking purposes by the shunting method an arrangement, as required in Rule 1, is possible but not practicable, and if installed may lead to complications and serious trouble that would prove far worse than the derangements which the shunts were designed to prevent.

Rule 2:—All connections or contacts depended upon for cross protection must also be used in operation, so that any failure or break which would impair their usefulness as a cross protection medium would also prevent the operation of the signal or switch, thus acting as a constant automatic check without the use of any extra contrivances for this purpose.

As Rule 2 covers the safest method of applying the shunt cross-protection recommended in Rule 1, it will, of course, not be applicable to electric locking circuits.

Rule 3:—A device receiving energy should have all controlling contacts located between it and the source of energy, thus having one side of the device connected, (a) directly to common so that no controlling contact will be shunted out in the case of a ground, or (b) directly to battery so that the controlling contacts will be shunted out in the case of a ground. The application of requirements (a) and (b) in Rule 3 depends largely upon whether the circuit considered is to be an open circuit or a closed circuit proposition, and whether the release of a locking circuit or the safe operation of a locking device is depending upon the pick up of a relay or the dropping of a relay. An example of the arrangement of a circuit meeting the requirements (a) in Rule 3 is shown in Fig. 6. The relay or device (c) is normally energized and all controlling contacts—being relay, switch box, signal or lever contacts—are located between the relay and battery positive, while battery negative is connected directly at the coil. It will be noted that a cross between wires 1 and 2 as at "X" will shunt out relay C and cause its de-energization, which in the present case will be on the side of safety. A ground to common at "Y" will also shunt the relay out.

Had the circuit been arranged as shown in Fig. 7, where positive battery is connected directly at the coil, a cross at "X" would cause the relay to stay picked up, thereby not only creating a dangerous condition, but also preventing its discovery until possibly a wreck or derailment would call the operator's attention to the derangement. A ground at "Y" would also cause the energization of the relay. Fig. 8 represents an open circuit proposition, and here the safety of the circuits controlled through the relay depends upon its de-energized state. Thus, a cross at "X" between wires 1 and 2 will cause the energization of the relay by the shunting out of the controlling contacts, and a ground at "Y" will also pick up the relay. A couple of simple circuits will

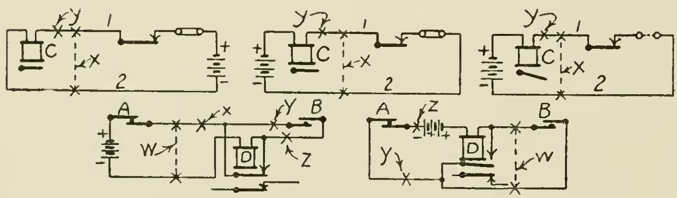


FIG. 6. FIG. 7. FIG. 8. FIG. 9. FIG. 10.

clearly demonstrate the application of either requirement: stick relay circuits will be shown as examples. Fig. 9 shows a normally energized (normally closed) stick relay circuit which, for simplicity's sake, is arranged as controlled by track instruments. Track instrument "A" is the starting or locking instrument, while "B" is the releasing or, in this case, the pick-up instrument. "A" is a normally closed and "B" a normally open track instrument. This being a closed circuit arrangement, the devices to be controlled will naturally be broken through the front points of the stick relay "D," which again means that the release or the normal condition of the electric locking is depending upon the energized state of relay "D," and its de-energized position should indicate a danger condition. It will be noted that the breaking of the contact on instrument "A" will drop the stick relay, which will not pick up again until contact on instrument "B" is closed. A cross between the control wires as at "W" will cause the dropping of the relay, and grounds at "X," "Y," "Z" or any place in the circuit will have the same effect. The opposite of what has been said in regard to Fig. 9 is true in regard to Fig. 10. Here

the relay is normally de-energized and any cross or ground should cause its energization, as the circuits to be controlled by it are broken through back points. In this circuit the closing of track instrument "B" will energize the relay, and the breaking of "A" will again cause its de-energization. A cross between the control wires at "X" will energize relay, and the same will be effected by a ground at "X.' A ground at "Z" and "Y" after the relay has been picked up will keep it in an energized state.

There are exceptional cases where the connecting of positive battery to a normally de-energized relay should not be arranged, that is, in places where the energization of the normally de-energized stick relay will release the electric locking. In such cases, of course, negative battery should be connected directly at the relay coils.

It will be well to bear in mind when considering cross protection in circuit designing that the possibility of a ground or a wire taking common through some faulty insulation is greater than the chance of positive battery current being introduced into same through a cross.

The observation of the rules just set forth is most essential for a successful result in all cases where apparatus is to be safeguarded against crosses.

II

THE TRACK CIRCUIT

Introductory. Almost every style of electric locking arrangement requires a track circuit as a lock or release medium and, while the purpose of electric locking is to safeguard an interlocking plant from negligence on the part of the operator, it is of vital importance, in designing such protection, that the track circuit is given due consideration. Without a proper co-operation in the workings of the track circuit and the locking features, the protection cannot be considered complete. While one style of electric locking may suit a certain condition, it must be understood that there is the choice of a number of different styles or arrangements of track circuits which might be employed in connection with it. The more elementary principles and applications of a track circuit are too well known to need any description. In the present article, therefore, there will be treated only the arrangement of track circuits at interlocking plants so far as it affects the electric locking of such plants, and also the most advantageous methods of insulating in order to derive the most complete protection possible for existing conditions from an electric locking point of view. Broadly speaking, track circuits may be divided into two distinct classes, viz., the normally closed and the normally open track circu[illegible] Each class may again be subdivided into single rail and double rail circuits.

The Normally Closed Track Circuit. Of these the normally closed track circuit is the one principally in use, being the most dependable, particularly in places where the track circuit is employed for the semi-automatic control of the signals in addition to the electric locking. The normally closed track circuit derives its name from the manner in which the track relay is energized, as the track section being unoccupied and the rails unimpaired, the battery will keep the track relay energized by a constant flow of current. Thus, a circuit maintained on the closed circuit principle will very effectively give warning of many dangerous conditions in a signal system. It will, by causing the de-energization of the track relay, give warning of the presence of a train, a car detached from a train, broken rail, and by proper arrangement of insulated joint will detect a car inside the clearance of fouling

point at sidings, or an open switch where an outlying switch is located within the limits of an interlocked home signal.

The Normally Open Track Circuit. The normally open track circuit is used to a very limited extent and principally only in places where non-automatic signals are in use and where the track circuit is employed for no other purpose but the electric locking. Contrary to the closed track circuit, in the open circuit scheme the presence of a train will cause the energization of the relay. The principal reason for the very limited employment of the normally open track circuit is because there is no certainty of the relay picking up. Any failures of the apparatus, such as a broken rail, exhaustion or breakage of the battery cell or the breakage of any of the wires will, of course, render the apparatus inoperative; besides, such failures are not readily detected, as they merely maintain the apparatus in its normal condition. With the normally closed circuit the reverse is true, as here any failure will be almost immediately detected and also be on the side of safety.

Single and Double Rail Circuits. Single rail and double rail circuits can be employed in normally closed and normally open track circuits. The term "single rail circuits" is derived from the fact that only one rail in each part of the circuit is insulated. The employment of a track circuit of this kind is made principally to avoid the expense of additional insulated joints, insulated front and head rods, tie plate insulations and in some places pipe line insulations, or where one rail is needed for other circuits. A single rail track circuit, however, is more liable to failure than one having the two rails insulated, for a number of obvious reasons the details of which it would be beyond the scope of this article to enter into. The common rail is the term generally applied to the rail in which there are no insulated joints; one reason for this being that it is often used as a common for additional circuit. In the following circuits this rail is, for the sake of distinction, shown in heavy lines.

Normally Open Circuits. A single rail application of a normally open track circuit is shown in Fig. 11. The insulated joints, while often placed at the signal, are here placed inside of

the derails, thereby avoiding the expense of insulated switch rods for the operation of the derails. It is a common practice, at plants for single track crossings having a track circuit which extends only between the home signals for the operation of the electric locking, to arrange the insulated joints at the derails in this manner, as the space between the signal and the derail point is

FIG. 11A.

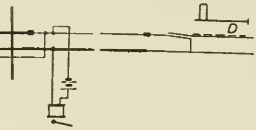


FIG. 11.

generally protected by the detector bar "D," and thus the requirements for the electric locking protection of the plant are fulfilled. The track circuit is transposed at the crossing by connecting a jumper as shown.

Transpositions. The transposition of a track circuit is effected by the placing of insulated joints and jumpers at some place within a track section in such a manner that the polarity of the adjacent rails in the same track section is reversed. The reasons for transposing a D.C. track circuit are manifold. A high potential difference between the rails, effected by foreign or stray current from electric roads operated in a close vicinity to the track, may be one reason for inserting a transposition in a track circuit, in this way providing a low resistance path for the stray currents across the rails through the jumpers, thereby diverting the stray current from the track relay. This will be more clear to the reader with a double transposition as shown in Fig. 11a. Stray currents flowing, as shown by arrows "X" and "Y," will flow through jumpers and back toward their respective sources (arrow "Z") without interfering with the track circuit operation. Another reason for the necessity of transposition is to limit the dead section in a track circuit where two roads cross each other at an oblique or acute angle, or where a switch in a section is so located that a proper insulating warrants it.

"Dead" Track Sections. Fig. 12 shows a single rail application of a normally open track circuit with a switch in the block.

The expense of additional insulated joints and insulated switch rods is here avoided by the use of two insulated joints and a jumper and by the transposition of the track circuit. By this transposition arrangement the "dead" section is limited to about 20 feet or less, so that no car or engine can stand in this section without affecting the working of the relay. In this connection it

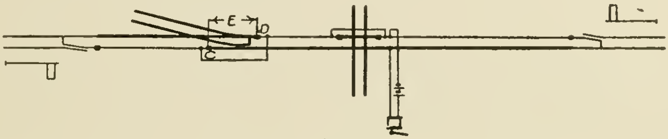


FIG. 12.

might be well to call attention to the fact that a track circuit, in order to afford full protection and fulfill the requirements made of it, must be so designed and constructed that each rail of a certain length of track carries a current of opposite polarity, as the part of a track where the rails happen to be of the same polarity is cut out or constitutes what is generally termed a "dead section." A dead section in a track circuit is frequently inevitable, but the object should be to make this section as short as possible so as to prevent a car standing across the rails in the dead section without causing the track relay to indicate its presence. Hence, in a case like the present, the insulated joints "C" and "D" should of course be placed as nearly opposite as possible in order to reduce to a minimum the dead section. In single

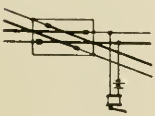


FIG. 13.

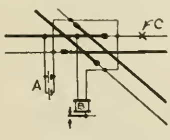


FIG. 14.

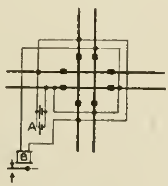


FIG. 15.

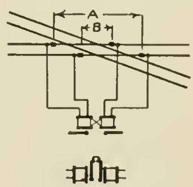


FIG. 17.

rail circuits it should always be observed that the rail insulated will be the one to whom battery positive is connected, as an arrangement to the contrary will facilitate the grounding of battery positive and, while not necessarily causing the false energization of the relay, certainly will cause a constant drain on the battery. Fig. 13 shows the application of a single rail open cir-

cuit at an oblique crossing where track circuit protection is provided for both roads. It is to be noted that the joints at the crossing are arranged so as to transpose the circuit with a view to limiting the dead section and at the same time providing a common rail. It is, furthermore, to be noted that a train entering the track circuit from any direction will cause the energization of the relay.

Normally Closed Circuits. The most simple and at the same time very efficient normally closed track circuit is illustrated in Fig. 14. This is a single rail circuit and it will be observed that the relay "B" is normally energized by battery "A" through a series of jumpers connecting each of the positive rails of the crossing. The relay could be energized by the placing of the track battery and the relay in series with connection to only one positive and negative rail, but by employing the jumpers as a connection between the battery and the relay a constant automatic check is obtained which will detect the breaking of any one or all of the jumpers, such an occurrence causing the de-energization of the relay. Fig. 15 shows the scheme used in connection with a right angle crossing. The similarity of this scheme to that shown in Fig. 14 will be apparent.

It should be obvious, however, that a circuit, where the battery used for the energization of the relay is connected close to or at the relay, cannot be perfectly safe, because a break of any rail will prevent a train from shunting the relay. An inspection of Fig. 14 will show that a break of a rail at "C" would prevent a train entering that part of the track circuit from shunting the relay until the train had passed the rail break.

Location of Relays. There are places where it is considered necessary to have the electric locking of a plant take effect upon a train passing the home signal from either direction and not released until the train has passed the crossing. In such cases four separate track circuits will necessarily be employed, and a circuit of this kind using single rail circuit is shown in Fig. 16. It is a well-known fact that in order to expedite the release of the armature of a track relay the relay should be located at the home signal and that the battery ought to feed the relay against the current of traffic. This, of course, is not possible on single track

roads where high speed trains run in either direction. On double track roads this rule should be strictly observed, although at interlocking plants the track sections as a rule are short, and it is immaterial at which point of the track section the relay is located. Hence, it has become the general practice in cases where it is necessary, to have the track circuit terminate at the crossing, to locate the relays there, as they may thereby be placed in the interlocking tower and thus effect the saving of a considerable quantity of wire, all the wiring being confined to the tower.

In connection with the circuit (Fig. 16) it will perhaps be well

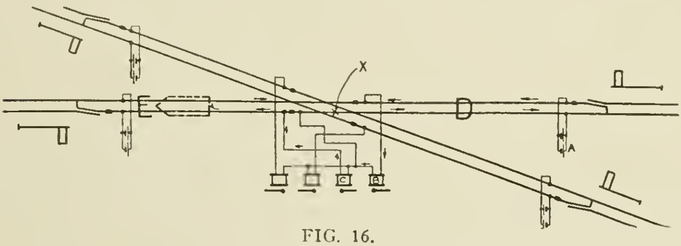


FIG. 16.

to call attention to one error which may easily be committed when designing or installing a circuit of this or a similar kind where one common connection is possible from one side of the relays to the common rail. It will be noted that the common side of the relays are joined with jumpers and one wire connecting the relays with the common rail. This should be avoided for the reason that, should, for instance, a break occur in the frog rail at "X," it would not only remain unobserved, but a train in section "E" would keep track relays "C" and "B" energized in series through the circuit, as indicated by arrows. Another style of a circuit for a grade crossing which may be used to advantage is shown in Fig. 17. Here an interlocking relay serves the purpose of locking, and the circuit used in connection with this arrangement may be designed so that both coils of the relay must be energized in order to release the locking, and this can only occur after the train has completely passed out of both track sections. The circuit can also be arranged so that a train passing out of one track circuit into the other will release the electric locking of the crossing. In this latter case an interlocking relay of the style shown at "C" will have to be employed, as described in Chapter I. To further prove the necessity of employing a com-

mon rail at acute angle grade crossings, both rails have been shown insulated in this figure. The dead section affected by this arrangement is indicated by distance "A," that is the distance between the two extreme joints. By using a common rail and only two insulated joints the dead section is reduced to distance "B."

Fouling Protection. The fouling point is that point on converging tracks where a car running toward some other point will come in contact with a car or train standing or moving on the other track. Thus, by providing fouling protection for a certain piece of track it will prevent a car from standing on a turnout or near a crossing so close that it would endanger a train passing on the main track. This is usually accomplished by extending the track circuit to a point on a side track where there is sufficient clearance between the two tracks. At interlocking plants a derail and detector bar is usually placed at such points, and no train can proceed beyond this except with the sanction of the operator, this sanction being expressed by the clearing of the signal situated near the derail, the lever locking between the derail and the signal providing against the clearing of the signal until the derail has been properly closed. The detector bar will prevent the derail from being thrown to its normal position should a car happen to be standing upon it, and this in turn, by the aid of the mechanical locking in the interlocking machine, would prevent the clearing of a signal on the main track until the release of the detector bar had proven that a movement of a train on the main track would be secure against collisions or sideswiping. On well-protected plants, however, this protection is not considered sufficient, for the reason that the fouling point on a turnout may extend from 200 ft. to 400 ft. away from the main track, and several cars may be standing between the derail and the turnout starting point without interfering with the working of the detector bar. Thus, the employment of fouling circuits at interlocking plants is considered very necessary in connection with the derails provided for the fouling protection of main tracks.

Broken Rail Protection. It should be recalled that the tendency of a broken rail or the presence of a car to de-energize the

track relay will be practically the same if the occurrence takes place anywhere in the track circuit between the point where the battery leads and the relay leads are attached to them. Hence, it should be apparent that in order to provide all protection possible the leads should be connected to the rails at the extreme ends of the circuit, keeping as much rail as possible in series with the battery and the relay. A true appreciation of these facts should greatly assist the reader in obtaining a correct conception of the advantages derived from the different schemes for effective fouling protection to suit various conditions.

Classification of Fouling Protection. There are three distinct ways to secure fouling protection, and these are:

1. By the so-called multiple or shunt fouling in which the fouling protection is secured by simply arranging the insulated joints so that the rails of the turnout will consist of one rail of each polarity; in other words, constitute a shunt to the main circuit.

2. By the series fouling in which the fouling circuit is so arranged that one or both rails of the turnout are connected in series with the track battery for the main track circuit, and the rails thus used in the control of the track relay in the main circuit.

3. By the employment of a separate circuit, either operated independently of the main track circuit by the use of an extra relay and track battery, or operated in conjunction with the main track circuit by using its track battery and a separate relay.

Of the three schemes the shunt fouling is the one most commonly used at interlocking plants, although for several reasons it is conceded to be inferior to the others with respect to the protection afforded.

Shunt Fouling. The reasons for its extensive use can be accounted for when considering the close attention and inspection bestowed upon apparatus and track connections at an interlocking plant. It is much more simple than any of the others, requires less insulated joints, and the quantity of wire necessary for jumpers is reduced to a minimum. The matter of reducing the number of insulated joints does not merely represent the item of cutting down the initial cost of a certain plant, but the future maintenance must also be considered, and the up-keep of an in-

creased number of joints at a large plant will in time add considerably to the operating expenses.

SERIES FOULING. The series fouling is used only to a limited extent at interlocking plants, due to the increased number of insulated joints and jumpers required, and also on account of the necessity of the placing of extra insulated joints in the main line rail. It gives more protection than the shunt fouling. However, when summing up the situation as to whether to employ shunt or series circuit at a certain location, it is merely a question of track conditions, and if the advantages present from a protection standpoint outnumber the disadvantages existing when seen from an operation point of view.

SEPARATE FOULING CIRCUIT. The third scheme of employing a separate circuit is decidedly the one most preferable, but it requires additional track relays, introducing increased maintenance expense, so its use is mostly restricted to places where the fouling circuit is of a prohibitive length, which would either make a series fouling too complex or expensive or a shunt fouling too unsafe or unreliable.

FOULING AT GRADE CROSSINGS. A grade crossing showing the application of a shunt fouling with the employment of a single rail track circuit is illustrated in Fig. 18. A train moving towards

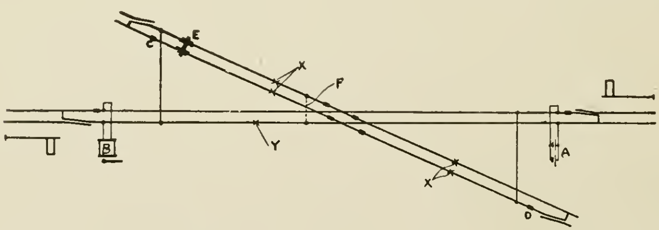


FIG. 18.

the crossing from either direction on the fouling track will, as soon as the first pair of wheels have passed either the insulated joint "C" or "D," shunt the track relay "B." The most serious objection offered to the shunt fouling is the possibility of the breaking of any of the rails in the fouling circuit as at "X," or the jumpers 4 and 6, will render the fouling protection ineffective

and would remain undetected until discovered either on inspection or when a car within the fouling limits would fail to de-energize the relay. In view of this it should be evident that as far as the turnout or crossing tracks are concerned, no broken rail protection is provided in the shunt fouling scheme.

In connection with the description of the shunt fouling, atten-

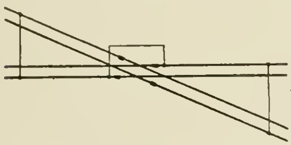


FIG. 19.

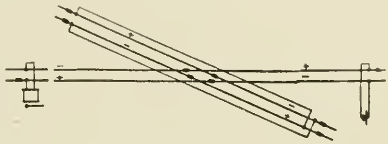


FIG. 21.

tion will be called to one error which is often committed when laying out circuits of this kind: that is the placing of an extra jumper for each fouling circuit and locating the jumper close to the insulated joints near the main track. The object in employing this additional jumper is to provide against the occurrence of the breaking of the jumper 4, which would render the fouling circuit ineffective and in which case Jumper "F" would keep the protection intact. A broken rail in the main track at "Y" would remain undetected with the employment of this jumper and keep the track relay energized through rail 1, relay coils, rail 5, jumper 4, rail 3, jumper "F" and rail 5 to battery. A shunt fouling applied to a grade crossing, while it is undesirable to insulate the frog rails, is illustrated in Fig. 19, and the description of Fig. 18 also applies to this figure.

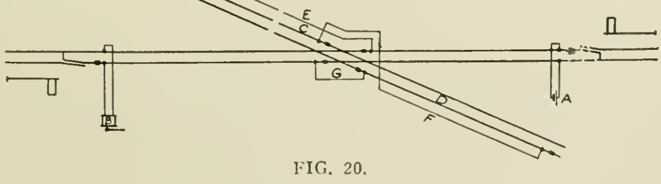


FIG. 20.

A series fouling used in connection with a grade crossing is shown in Fig. 20. A single rail track circuit is employed and only one rail of the fouling circuit is connected in series with the main track circuit. It will be noted that in this circuit the breaking of the rail "C" or "D" or the disconnection of jumpers "E," "F" and "G" will immediately be detected by the dropping of

the track relay "B," this being the advantage of the employment of series fouling protection. Fig. 21 illustrates the series fouling applied so as to connect all the rails in series with battery and relay. This may prove advantageous where the fouling distance is very short, but for longer distances it is not considered practicable to develop the series arrangement this far. The arrange-

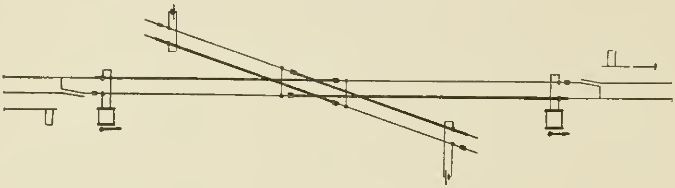


FIG. 22.

ment shown in Fig. 22 will be found very suitable at places where the fouling point is of some distance from the main track and where it is desirable to connect both rails of the fouling circuit in series with the main circuit with a limited use of jumpers and insulated joints. Here two track relays and batteries are employed and one rail of each track used as a common. This may be considered the most favorable arrangement for a track condition of this kind. The scheme of employing separate circuits for fouling protection of grade crossings is similar to the circuit shown in Fig. 16.

Fouling of Turnouts. The fouling protection employed for a turnout or the junction of two main lines is shown in Fig. 23.

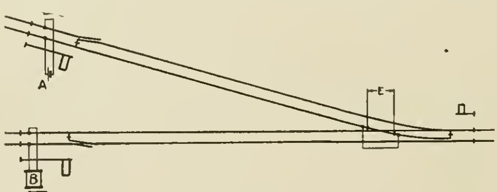


FIG. 23.

A shunt fouling circuit would provide a very incomplete and unreliable protection for this condition, as both tracks being main tracks and the signals situated not less than 500 ft. from the switch, the fouling circuit would be of too great a length. A series circuit as shown will be very appropriate. Here only one jumper and two insulated joints are employed, and both rails of

both tracks used for the current from battery "A" to energize relay "B." The dead section, which is unavoidable in this arrangement, may vary in length from 15 ft. to 30 ft., depending on the number of frogs used. The short section, about 55 ft. between the switch point and the dwarf signal, may be considered a shunt fouling to the main circuit because these parts of the rails are not used in the control of the track relay.

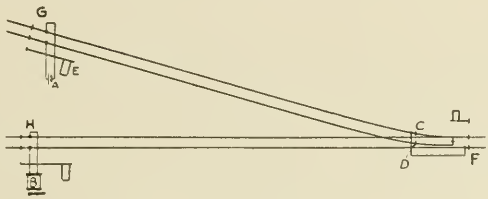


FIG. 24.

Another arrangement of a track layout of a similar kind is shown in Fig. 24. Here also a series circuit is employed, but the dead section is entirely removed, the insulated joints "C" and "D" being very slightly staggered. By placing the jumper as shown the shunt fouling of the piece of track between the dwarf and the switch has been confined to one rail only, the other being connected in series with the main circuit. The disadvantage of the circuits shown in Figs. 13 and 14 is the necessity of the placing of the battery at one signal and the looping around the switch to the relay at the other signal. This arrangement not only necessitates a series track circuit of considerable length, but other conditions, such as slow release of the relay armature, circuit selections, etc., often make this arrangement undesirable. In a separate circuit fouling protection the battery should be placed at "F" and a track relay at "G" and "H."

Fouling of Switches. The fouling protection required for switches at sidings is in many respects similar to the arrangements covered in connection with main track turnouts, and the three principal methods employed are identically the same. At places where no section locking is employed the simplest way to take care of switches is to jump around the switch by the use of insulated points and jumpers as shown in Fig. 12 and Fig. 25, the first one being applicable to single rail and the latter to double rail circuits. In Fig. 15 no insulated switch roads or connections

are necessary, but a dead section of from 33 ft. to 66 ft. is present. With this circuit a broken rail at "X" will not be indicated by the track relay, the current taking the path as shown by the arrows. The insulated joint "A" may be placed at fouling point "A" and joint "B" and jumper "C" added. By this arrangement a shunt fouling is added to the track circuit protection. Another

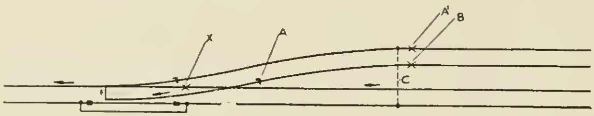


FIG. 25.

arrangement giving very inadequate protection is that in which the switch rail is separated from electrical connection with the main rail by means of wedges or wedge blocks, but this scheme is only applicable to certain styles of electric locking.

The most common arrangement of fouling protection for

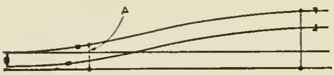


FIG. 26.

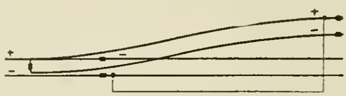


FIG. 27.

switches at interlocking plants is illustrated in Fig. 26. A shunt fouling protection is here afforded by the use of four insulated joints, a jumper and insulated front and head switch roads. The objections to the use of the jumper "A" were covered in the description of Fig. 8.

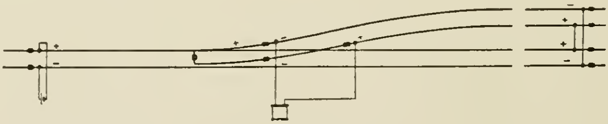


FIG. 28.

A simple series fouling circuit is shown in Fig. 27. It will be noted that the outside rail of the sliding is connected in series with the main track rails. With this arrangement borken rail protection is given for the outside rail, this rail being the most important on account of the side strain imposed upon it with a train moving towards the switch. Where the track circuit terminates at or

close to the foiling point of a siding, very favorable arrangements of fouling protection can be procured and without the placing of any insulated joints on the main track. Fig. 28 illustrates perhaps the best possible arrangement of a series fouling circuit of this kind, using the least number of insulated joints and having the length of the jumpers reduced to a minimum.

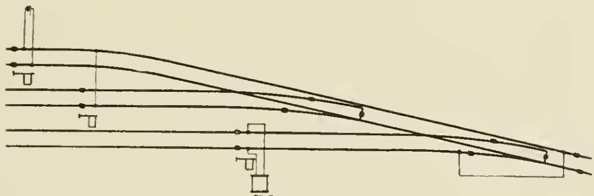


FIG. 29.

Ladder Tracks. When a series of turnouts connect a straight main track with a number of parallel equally distant side tracks, the whole arrangement of tracks is called a "ladder track." Ladder tracks are very commonly employed in large yards, and a convenient way of arranging the circuits is shown in Figs. 29 and 30. In Fig. 29 two turnouts are connected in series, while the third is provided with shunt fouling protection. While no dead section is present in this circuit, it does not provide as much protection as the circuit, Fig. 30. One battery here supplies current for two relays and, of course, where more turnouts occur in one ladder track, additional relays may be connected in a similar manner with one battery. The presence of a train on any

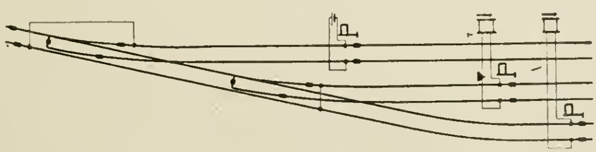


FIG. 30.

parts of the circuit will, of course, drop all the relays connected in multiple with one battery, but as no parallel movements are possible this is a good feature. It is possible also to provide series fouling with ladder tracks, but on account of the number of additional joints and jumpers required and the somewhat complex arrangement resulting, this method is not to be recommended.

Fouling of Lap Switches. The shunt fouling of a lap switch is shown in Fig. 31. The negative rails are indicated in heavy lines.

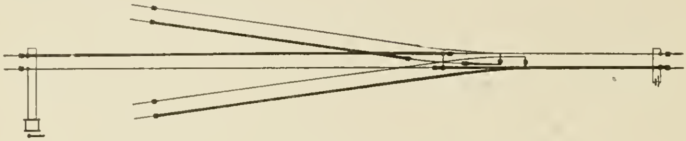


FIG. 31.

Fouling of Crossovers. Fouling protection is also required for crossovers so that a movement over it will shunt the relay for either one or both tracks. There are two distinct ways of providing fouling protection for a crossover. The one is, where a crossover connects two main tracks, in which case the crossover is made to shunt partly one and partly the other track. The other case is where a crossover connects a main and a side track, in

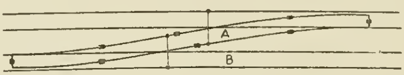


FIG. 32.

which case the crossover will shunt only with the main track.

Fig. 32 shows the method of fouling protection most frequently employed for a main to main crossover. It will be noted that this circuit will come under the class of shunt fouling. A car standing on the center of the crossovers between both tracks will affect the relays ffor both track circuits. It should be noted, however, that with crossovers connecting tracks of ordinary spacing, complete fouling protection cannot be obtained. Thus, it is possible for a car

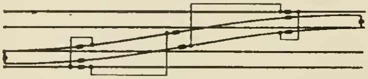


FIG. 33.

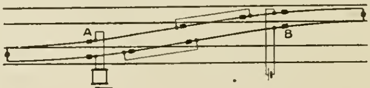


FIG. 34.

to partly stand on the crossover as at "A," and while thus fouling track "B," will not affect its track relay. A broken rail or jumper in the crossover circuit will permit a car to be standing on the circuit without affecting the track relay for the track whose fouling circuit is impaired. A more complete fouling protection is procured with Fig. 33 for a main to main crossover, using the

scheme of series fouling, one rail of the crossover being in series. Perhaps the highest development of crossover protection for main to main track is illustrated in Fig. 34. Here a separate circuit is used and the fouling protection carried as far as possible toward each track. A train standing on either track will not affect the crossover relay, which will only respond with a pair

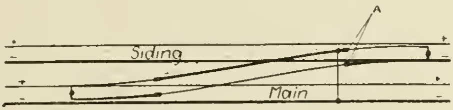


FIG. 35.

of wheels passing over the joints at point "A" or "B." The circuits controlled through either main track must be carried through crossover relay in order to obtain desired fouling protection. In most cases the breaking of the main track circuits through the crossover relay will greatly simplify the circuits through the plant. This, however, will necessitate the placing of insulated joints in the main rail which, of course, is undesirable. Shunt fouling protection for one track only where single rail circuit is employed is shown in Fig. 35. This circuit may be considered a very good arrangement with the use of a limited number of insulated joints and jumpers, and, as explained, a pair of wheels passing joints "A" will shunt the main track relay.

Fig. 36 provides the same protection and is in most respects similar to Fig. 35, with the exception that the circuit is entirely separated from adjacent track circuits by the employment of

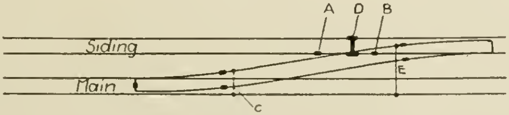


FIG. 36.

insulated joints "A" and "B." While this extra precaution may not appear necessary when considering a single crossover between two tracks, there are places where the omission of these joints may cause complications, especially where other crossovers should join the main track with the secondary track, whether directly or indirectly. Transpositions of the track circuit for the

siding may also be necessary if the joints "A" and "B" are left out. Thus, on track layouts offering complications in the nature of crossovers and turnouts the employment of the additional insulated joints is not only urgent, but very necessary. As previously stated, in connection with shunt fouling protection for switches, the jumper "C" should be omitted. The circuit shown in Fig. 36 also provides protection at places where troubles from foreign current are likely to occur. This will be evident when considering that a car standing at "D" will allow foreign current to flow towards the main track circuit over jumper and may cause derangement of this circuit.

PASSING CENTER TRACK CROSSOVER. The fouling protection of three tracks running into two tracks is shown in Fig. 37.

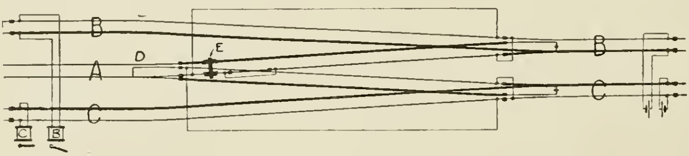


FIG. 37.

Series fouling is applied to this circuit and a train approaching track "B" from track "A" with switch "D" normal will shunt track relay "B," as shown in the figure—"E" representing a pair of wheels. With switch "D" released and a train passing from track "A" to "C" the track relay "C" should be shunted. Attention will here be called to one thing very important to observe when laying out the track circuits at an interlocking plant, and that is the arrangement of the circuits with the object in view of maintaining the flexibility of the plant by permitting parallel movements to take place simultaneously. This, inasmuch as the signaling of a yard is installed as much for the acceleration of traffic as for its protection. Thus it must be observed that it should be possible for a train to move from track "A" to "B" over switch "D" normal without interfering with a movement over track circuit "C." That is, in the present case the fouling protection for either track "B" or "C" should be so arranged that if a pair of wheels should bridge track "A" at "E" only the track relay for circuit "B" should be shunted, while track relay "C" should not be affected, because a movement over this track

would not be endangered in such a case. The same should obtain with the fouling of track "C," and a train moving over track section "B." This is very effectively accomplished in the present figure without much complication in the track circuit arrangement. The other features of this circuit are self-explanatory.

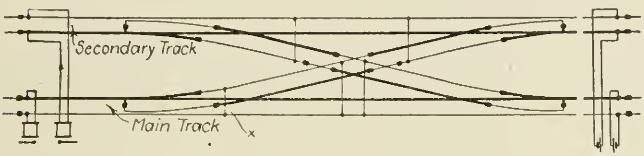


FIG. 38.

FOULING OF SCISSORS CROSSOVERS. One method of insulating scissors crossovers having stiff frogs is shown in Fig. 38. The circuit is arranged so that more fouling protection is provided for the main track than the secondary. It should be noted that shunt fouling is provided. In this, as in other schemes of shunt fouling, the additional jumper shown dotted at "X" should be avoided. Another method of insulating scissors crossovers between two main tracks is shown in Fig. 39. Equal fouling protection being desired for each track, a dead section in the frog rails cannot be avoided. Section "A" is dead.

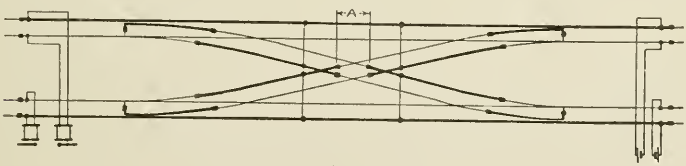


FIG. 39.

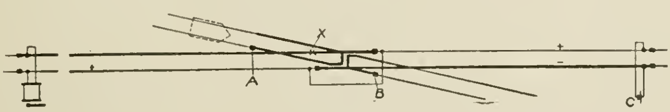


FIG. 40.

MOVABLE POINT FROGS. The simplest way to provide for the continuation of a track circuit through a movable point frog would be to transpose the circuit and jump around the frog points as shown in Fig. 11 and other figures. In Fig. 40 no fouling pro-

tection is employed, but joints "A" and "B" are placed in the turnout rails to prevent a leakage. Another reason for placing these joints as shown is to prevent a broken rail at, for instance, "X" to remain undetected. This will be evident when following current from positive side of battery "C," positive rail, relay coils, negative rail to "X," rail 1, wheels of car, rail 2 and nega-

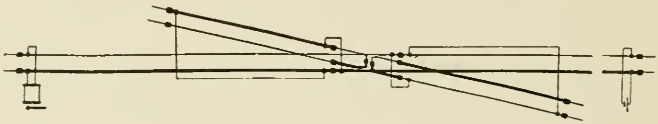


FIG. 41.

tive rail, back to battery. Thus a car on turnout and a broken rail at "X" will keep track relay energized.

Series fouling of a movable point frog is illustrated in Fig. 41. As previously stated the disadvantage of a circuit of this kind is the location of the extra joints in the main track rails.

Slip Switches. The existence of double and single slip switches within an interlocking often complicates an otherwise simple track circuit arrangement. While some roads entirely shunt out such switches on acount of the complications met with when attempting to maintain a positive and negative rail through them, other roads are as precise in their track protection of these switches as for the crossovers and switches. An elaborate arrangement of a track circuit carried through a double slip switch, where the insulating of the switch has been partly completed, is shown in Fig. 42. Here the dead section "A" has been

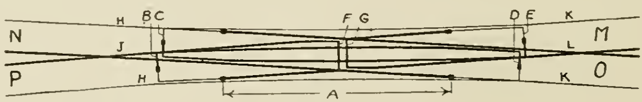


FIG. 42.

considerably reduced by the employment of four insulated joints and insulated switch rods. The dead section will be of 30 ft. length. This circuit cannot be used in connection with No. 8 and No. 10 switches. It should be noted that no dead section is present with a train moving from "M" to "N" or from "O" to "P." This will be apparent when comparing the thickness of the rails

of each piece of track touched by the wheels of the train passing over them, heavy and light lines representing opposite polarity of the track circuit. The single lines "B," "C," "D" and "E" connecting the switch points each represent the front rod, head rod and from two to four tie rods, but in order to simplify the diagram they are shown in a single line. Each one of these rods is insulated and the tie plates are cut to prevent an electrical connection between rails H—J and K—L. The single lines F and G at the frog points represent an equal number of rods as at the switch points, but these are not insulated.

Fig. 43 shows what is perhaps the highest development of double slip switch protection. No dead section is present in this

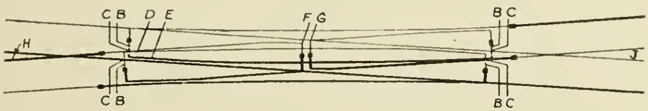


FIG. 43.

circuit with the same number of insulated joints as in the previous circuit. The description of Fig. 42 will also cover this figure. In this circuit the front, head and tie bars of the frog points F and G are insulated and the tie bars cut. It will be noted that in the diagram the switch rods "B" apparently touch rail "D" at the point "C." This would short circuit the track battery and shunt the track relay by the connecting of positive rail "D" with negative rail "E." This is prevented, however, by having the switch rods "B" downset so far below the rails "C" that the rods in either position of the switch points will not touch and make an electrical connection. Thus the lines shown dotted represent that part of the switch rod which is downset. It will be observed that in this circuit, while the complete lower part of the switch is of one polarity, the complete upper part is of another. That is, if a line is drawn through the switch from "H" to "J" the parts of the switch on each side of the line is of an opposite polarity. This is the most ideal condition obtainable with a double slip switch, and a train on any part of the switch will shunt the track relay controlled by the circuit. It should be understood that, while the circuits just presented are shown as applied to movable center frogs, they are also applicable to double slip

switches employing rigid center frogs. It should also be observed that in insulating slip switches a series circuit arrangement which would also give broken rail protection is not possible without complications which would be found prohibitive in railroad work.

Gauntlet Tracks. Where two tracks converge so as to occupy a space slightly greater than that required by a single track they are called gauntlet or intervolved tracks, and are used on tunnels, bridges, etc., where the necessary space for a double track is not available. Fig. 44 shows a gauntlet track circuit

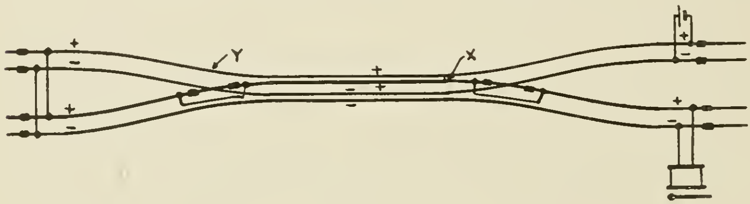


FIG. 44.

arrangement whereby only one battery and relay is required. In this circuit, if an electrical connection should accidentally be made between the two rails running close together, as at "X," the rails between that point and the jumper wires at the end of the section will be cut out of the circuit, and consequently a broken jumper wire or a broken rail at "Y" would not affect the operation of the track relay. The polarity of the rails must be arranged as shown, because if transposed a cross at "X" would create a battery short circuit. The best method of arranging a gauntlet circuit is to provide two separate track circuits and always have like polarity on the two rails closest together.

Conclusion. While in the present article d. c. track circuits only have been discussed, without reference to a. c. track circuits, it can be said that the arrangement of the latter will be similar in all cases, with the exception that proper provisions must be made for the return of the propulsion current for electric traction. A. c. single and double rail circuits are in use, the application depending upon whether one or both rails are given up for signaling purposes.

In regard to track circuits in general, it should be kept in mind that to connect a number of long track circuits together, by either

taking battery for all from a common source of energy or as single rail circuits, should be strictly avoided. This precaution should be taken principally to avoid the trouble due to foreign currents, and while it may not entirely overcome the bad effects from them, will at least minimize their effects. Another reason is the probability of having a train in one section short circuit or shunt an adjacent track section.

From the discussion it should be evident that the question of whether the track circuit is extended to detect broken rails or not enters very much into the decision of what kind of track circuit to employ. Strict attention must also be given to the effect that various failures may have upon the circuits, such as crossed wires, broken rails, defective insulations, broken bonding, poor wheel contact, low ballast resistance, battery failures and numerous others. All such failures must be taken into account when designing the circuits so that no dangerous conditions will ensue without readily attracting the attention of the maintainer. In that way only can perfect safety be insured.

III

TRAP CIRCUITS

General. A "dead" section is a section of track where no track circuit can be maintained, and its presence is a frequent occurrence in a track circuit proposition. It may often be of considerable length and is caused at bridges or trestles which, being built of steel, are constructed so as to receive the rails without the intervening wooden ties. It is also caused at places where steel ties, for some reason, are employed, or where a number of streets cross a railroad, a railroad crossing another, or any place where conditions prevent the proper maintenance of a continuous track circuit. In order to protect such places the only alternative is to employ a trap circuit for the safeguarding of train movements.

A trap circuit is really one type of a stick relay circuit in which the rails generally are used as a control circuit; but when in all cases a strictly automatic operation of the relay is secured by the movement of trains acting as an actuating medium without the contributory manual control of any parts of the circuit or devices. These types of track circuits are also employed in electric locking on account of offering a more economical installation problem, particularly in places where no continuous track circuit arrangement is desired. In a trap circuit one or more stick relays are employed for the purpose of making or breaking a circuit either with the intention of locking up a route or preventing the auto or semi-automatic clearing of a signal; in either case, preventing a train from proceeding until a preceding train has passed the dead section. It is also employed in crossing bell circuits to keep a bell in action until the streets compelling the dead section have been passed by the train. A trap circuit will necessarily consist of two mediums through which the locking and the release of the stick relay is effected, and these may either be track instruments or track circuits.

Trap circuits for single and double track roads should be arranged alike so that the protection will take place with traffic running in either direction. This is necessary because, not only should movements with the current of traffic be protected, but also back-up movements and possible movements against current of traffic. Circuits are employed, however, on double track

roads which only take care of the protection of movements with the current of traffic. On some types of trap circuits the arrangements for the protection of traffic for movements in one direction will have to be duplicated if protection for opposing movements is desired. While the figures are arranged showing a draw-bridge as necessitating a dead section, it is evident that it may constitute any condition previously described.

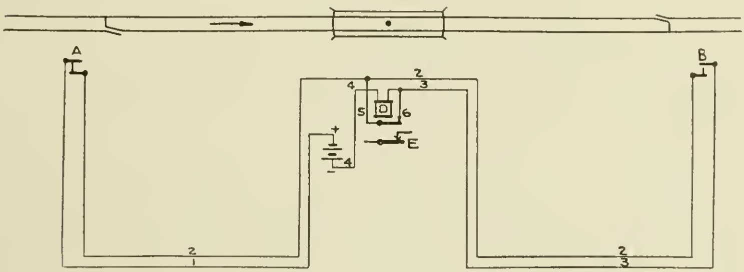


FIG. 45.

TRACK INSTRUMENT ARRANGEMENT. A trap circuit actuated by the means of two track instruments is shown in Fig. 45. This circuit is a normally energized stick relay scheme, and the track instruments employed are one having a normally closed contact at the starting end "A" and one having a normally open contact

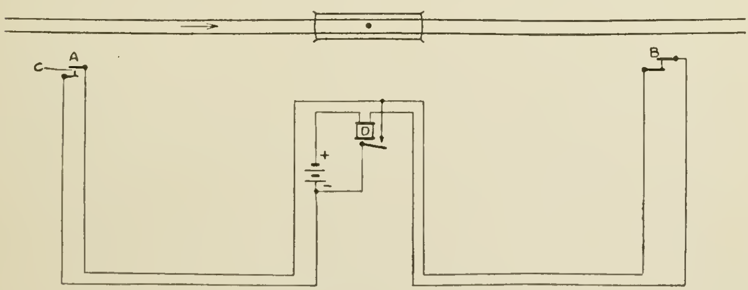


FIG. 46.

at the releasing end "B." The operation is as follows: A train moving in the direction of the arrow will, upon reaching track instrument "A," actuate this, thereby de-energizing stick relay "D," which will remain de-energized until the train has reached the releasing track instrument "B," when relay "D" will again pick up, through wires 1, track instrument "A," wire 2,

instrument "B," wires 3 and 4 to battery. It will stay picked up through wires 1, 2 and 4, its own front point, and wires 5 and 6 to battery. The control of the protective circuits will, of course, be through the front point "E." Fig. 46 shows the scheme as applied to a normally de-energized stick relay. The starting instrument "A" will here cause the energization of the stick relay "D" and the stick relay will again become de-energized upon the train reaching track instrument "B." It is to be noted that the circuits Figs. 45 and 46 will give protection for movements in one direction only, and if protection for both directions is desired another relay and set of track instruments are necessary.

Track Circuit Arrangement.

Effective in One Direction. A trap circuit employing track circuits as actuating mediums, and where protection is provided for one direction only, is shown in Fig. 47. "A" and "B"

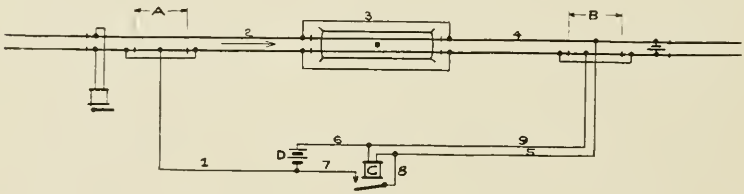


FIG. 47.

are pick-up and cut-out sections, respectively, and each section or rail is from 15 ft. to 30 ft. in length. This figure has a track circuit which is actuated and is in its operation the same as an ordinary track circuit, and entirely independent of the stick relay circuit. While a train is in the dead section on the bridge the track relay will, of course, pick up again. It will be observed that insulated joints and jumpers cut the dead section (a drawbridge is used in all the diagrams as an illustration) entirely out of the track circuit. A separate battery is in this scheme used for the operation of the stick relay "C." The circuit operates as follows: A train moving in the direction of the arrow will, when passing into section "A," energize relay "C" by current flowing from battery "D," track connection 1, wheels and axles of train, rail 2, jumper 3, rail 4, track connection 5, coils of stick relay "C" and wire 6 to negative side of battery. When the stick relay is thus picked up it will remain so through wire

7, its own front point, wire 8, coils of relay and wire 6 back to battery. With the train entering section "B" the current is shunted out of the relay through wire 7, its own front point and wires 8 and 5, wheels and axles of train and wires 9 and 6. It should be noted that in this scheme all circuit breaking through the track relay should also break through a back point of the stick relay "C." Like all open circuit schemes, the present circuit is susceptible to derangements characteristic of such circuit arrangements, and cannot be classed as perfectly reliable under all conditions. An open circuit scheme is, as previously discussed, based on the wrong principles, as there is nothing to give assurance that the stick relay will perform the duty to which it is assigned. For example, a break in a wire would impair its usefulness. The relay, being normally de-energized, will, of course,

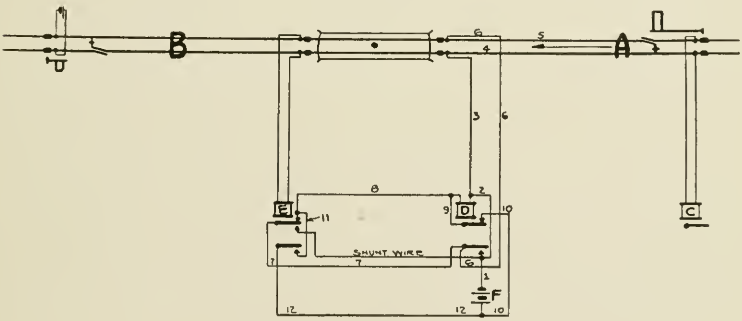


FIG. 48.

effect a saving in the battery consumption. By controlling the bridge shunt wires through the stick relay, the trap circuit will also keep the track relay down while the stick relay is energized.

Another trap circuit taking effect only when trains move in one direction is shown in Fig. 48. A train moving in the direction of the arrow will, when entering into section "A," shunt track relay "C" and stick relay "D" through the following circuit: From battery "F," wires 1 and 2, track connection 3, rail 4, wheels and axle of train, rail 5, track connection 6, wire 7, front point of relay "F," wires 8 and 9, front point of relay "D" and wire 10 back to battery. Relays "C" and "D" remain de-energized until the train has entered section "B" and dropped relay "E" for this section. Relay "C" will not pick up until relay "D" is energized, for the reason that with relay "D" dropped, battery positive is applied

to both rails in track circuit "A," one rail being fed directly from battery through track connection 3 and the other rail through back point of relay "D" and track connection 6. Relay "D" will pick up through circuit from battery "E," wires 1 and 2, coils of relay "D," wires 8 and 11, back point of relay "E" and wire 12 to negative side of battery. Relay "D" stick-up circuit is as follows: Battery "F," wires 1 and 2, coils of relay "D," wire 9, front point of relay "D" and wire 10 to battery. Relay "C" is shunted on back points of relays "D" and "E" for cross and foreign current protection. Relay "C" will pick up after train is out of section "B," and relay is energized through the following circuit: Battery "F" wires 1 and 2, track connection 3, rail 4, coils of relay "C," rail 5, track connection 6, wire 7, front point of relay "E," wires 8 and 9, front point relay "D" and wire 10 back to battery. While a broken rail in this circuit will not prevent the picking up of stick relay "D," it will prevent the picking up of track relay "C."

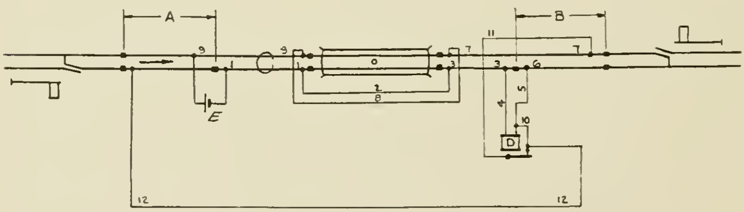


FIG. 49.

Effective in Both Directions. A trap circuit employing a normally energized stick relay is illustrated in Fig. 49. Single rail sections "A" and "B" are release and pick-up sections for stick relay "D," the function of each section depending upon the direction of the train movement. Each of these sections can be from 15 ft. to 30 ft. in length. The operation of the track circuit is as follows:

A train moving in the direction of the arrow will, upon passing section "A" and entering section "C," shunt relay "D," which will not pick up again until the train has reached section "B," when current will flow from track battery "E," track connection 4, coils of stick relay "D," track connection 5, rail 6, wheels and axles of train, rail 7, jumper 8 and rail 9 back to battery. This will energize the stick relay, which will remain picked up through

the former circuit and jumper 10, front point of relay "D" and track connection 11. A movement in the opposite direction will have the same effect, wire 12 connected to rail in section "A" then being used for pick-up purposes.

The circuit shown in Fig. 49 is a very simple and effective trap circuit, only employing one line wire and the track relay being

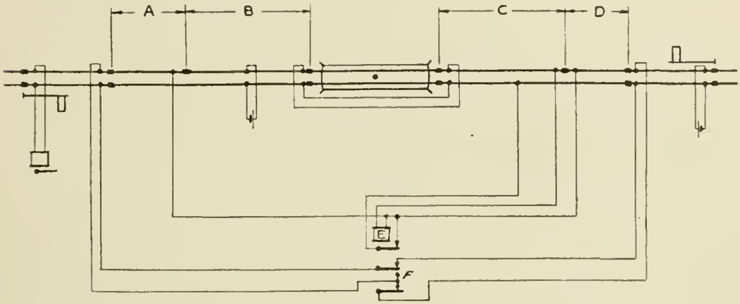


FIG. 50.

utilized as a stick relay. The trap circuit scheme employed in Fig. 50 is similar to the one shown in Fig. 49. In the present figure, however, an extra relay is employed as a stick relay, and through this relay the regular track relay is controlled, so that as long as the stick relay is down the track relay will also remain de-energized. In this way more protection can be procured than is possible in Fig. 49, where the stick relay will protect the dead

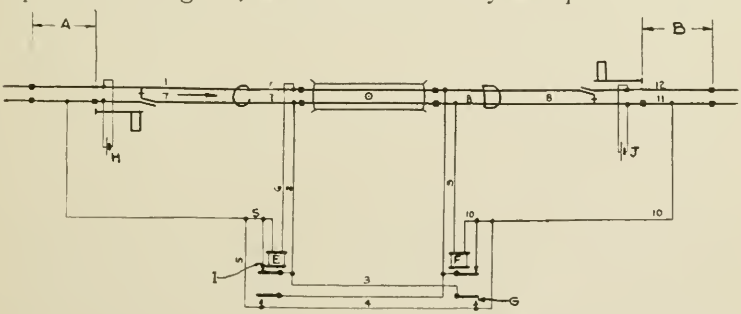


FIG. 51.

section; while in Fig. 50 the whole block can be protected. "F" is a protective shunt contact for the track relay while the stick relay is de-energized. Sections "A," "B," "C" and "D" are from 15 ft. to 30 ft. in length. From the description of previous figures this circuit should be readily understood.

The trap circuit shown in Fig. 51 employs two stick relays,

also functioned as track circuit relays, and two track batteries. Advance sections "A" and "B" are each from 30 to 60 feet long. Assuming a train to be moving in the direction of the arrow, first entering section "A," it will proceed into section "C" and shunt the relay "E" for this section. After the train has passed the bridge and proceeded into section "D," thereby dropping relay "F" for section "D," the back point "G" will be closed, which will complete the pick-up circuit for relay "E" as follows: From positive side of track battery "H," rail 1, track connection 2, wire 3, back point "G," jumpers 4 and 5, coils of relay "E," track connection 6 and rail 7 back to battery. Relay "E," being a stick relay, is held energized through the former circuit and its own front point "K." Relay "F" will remain de-energized until the train has completely passed out of section "D" and moving in section "B," when it is picked up by track battery "J," through rail 8, reaching connection 9, coils of relay "F," wire 10, rail 11, wheels and axles of train and rail 12 to battery. This relay also is held energized through one of its own points. The same operations will take effect if a train moves in the opposite direction to the one just explained.

The circuit Fig. 52 employs one track relay, also functioned as a stick relay, and advance sections which serve as pick-up cir-

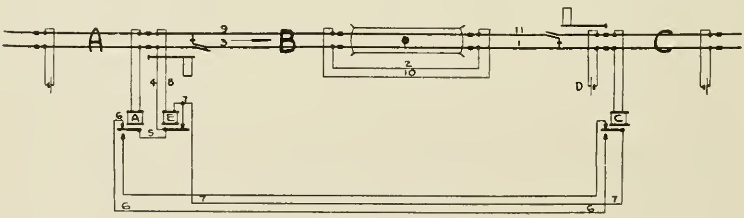


FIG. 52.

cuits. These advance sections can, of course, be of any reasonable length. A train moving in the direction of the arrow will shunt the stick relay "E" through the following circuit: From positive side of battery "D," rail 1, jumper 2, rail 3, track connection 4, wire 5, front point of relay "A," wire 6, back point of relay "C," wire 7, coils of relay "E," track connection 8, rail 9, jumper 10 and rail 11 back to battery. The stick relay, after the train has passed out of section "C," will stick through one of its own points. The same will take effect upon a train moving in the opposite direction.

Fig. 53 shows another trap circuit using a track relay, which is also employed as a stick relay. A train moving in the direction of the arrow will, upon reaching section "B," drop stick relay, and when train has entered into section "C" this relay will pick up through back point of track relay "C" and stick up through its own point.

Precautions in Design. In regard to trap circuits in general the following should be observed when they are applied for electric locking purposes: When a trap circuit is applied independently of the track circuit, as, for instance, in Fig. 47, it is obvious that, while a train when entering onto track section B will release the trap circuit and consequently the locking effected by it, the distance between this section and the bridge must be longer

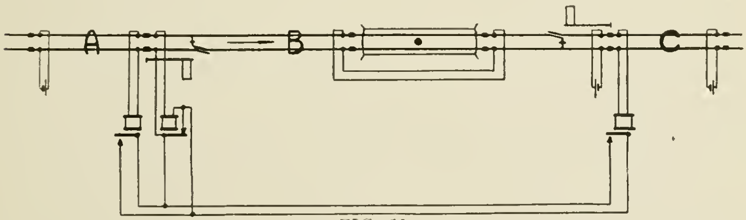


FIG. 53.

than the longest train expected to traverse the route. Should it be impossible to locate the releasing track section or track instrument at a distance far enough from the crossing to accommodate long trains, the lock used in the electric locking must also be controlled through some track circuit medium which will prevent the unlocking of the route until the train has passed out of the dead section or whatever condition the trap circuit was installed to protect.

A trap circuit installed for the locking and release of an electric locking arrangement can have the length of the release and locking track sections as specified in the description of the various schemes. As this distance is in all cases never made shorter than a rail length, and while proper for an electric locking proposition, it must be made shorter where a trap circuit is also employed for the semi-automatic control of signals. The length of the locking and release sections must not be sufficient to allow a car to stand in either of these sections without affecting the signals. Hence, in most cases, to insure full protection, it will be necessary to cut the rails at each circuit to provide shorter sections.

IV

INDICATION LOCKING

Definition. The nomenclature "Indication Locking" has been defined by the Railway Signal Association as being: Electric Locking adapted to prevent the manipulation of levers which would bring about an unsafe condition in case a signal, switch or other operated device fails to make a movement corresponding with that of the operating lever; or, adapted directly to prevent the operation of one device in case another device, to be operated first, fails to make the required movement.

For a correct conception of the advantages derived from the use of indication locking and the grave necessity for its employment in connection with power operated units, the reader should bear in mind the great difference existing between the control and operation of a mechanical and a power unit.

Dog Locking Protection. There are certain features which are common to all interlockings, namely, the arrangement of the mechanical locking in the machine. That is, the levers for the operation of the signals and switches are so interconnected through the mechanical locking between them that their manipulation can only occur in predetermined sequence, and in this way it is insured that only proper and non-conflicting routes can be set up for the movement of trains. With the reversal of the home signal lever all the switch and lock levers in the route over which the signal governs are locked in their normal or reversed position, as the conditions require, and all opposing signal levers locked in their normal position, thus effectively preventing the operator from reversing a lever either by mistake or inadvertence, which would cause the display of conflicting and dangerous signal indications. Thus, as far as levers are concerned, in neither mechanical nor power interlockings can two opposing signals be displayed simultaneously.

Indication for Mechanically Operated Signal. With the use of pipe or wire connected signals at a mechanical plant, there can be no doubt of their being thrown in accordance with the movement of the lever as the operator can readily ascertain whether a signal has performed the operation intended, or test

the integrity of the connection between the lever and the function by the "feel" of the lever. Should any obstruction prevent the signal from assuming the stop position, a failure of this kind would also prevent the lever from being placed in the complete normal position and consequently keep the route governed by the signal locked up by the mechanical locking. Furthermore, the signal blade and spectacle casting are constructed so they are thrown by a powerful force and with sufficient inertia to remove a retardation, and any breakage of connections will cause the signal to assume the stop position. Again, by arranging the cranks used in the operation so that the blade is pushed to the clear position instead of pulled, the accidental buckling of the pipe line will prevent the signal from assuming a clear position with the lever normal.

Indication for Mechanically Operated Switches. The conditions which obtain with regard to the operation of switches at a mechanical plant are somewhat different, as the possibility of the pipe lines breaking or buckling enough to allow the lever to be put in the full reversed position with the switch only partly reversed must be seriously considered. For this reason some form of locking is necessary and this is accomplished in two ways: by the facing point lock and by the switch and lock movement in conjunction with the bolt lock. The facing point lock is operated independently of the switch and by a separate lever, the full reversal of this lever giving assurance that the switch has entirely completed its movement. Thus it may be said that the indication locking for a switch at a mechanical interlocking plant consists in the ability of the operator to force a plunger which slides in a fixed casting through a hole in a sliding bar, which bar is fastened to and moves in unison with the switch points. If for any reason the switch points do not go to the proper place when the lever by which the switch is operated is thrown, it is obvious that the plunger cannot be thrust through the hole in the sliding bar and the switch cannot be locked, thus indicating to the leverman that the switch is not in a proper position.

Power Operated Units. With a power operated unit, the conditions are vastly different. Here by the use of electricity or any other form of power for the operation of the units the more

immediate control is transferred from the operator, who by the manipulation of the lever is merely causing the make or the break of a contact through which the unit is being operated. Therefore, it is not safe to depend upon the assumption that a unit has responded to a given lever movement and taken a position corresponding with the movement of the lever, as the circuit may be open at any one of a number of places so that current will not reach the unit at all, or the movement of a switch may be obstructed so that the motor or other actuating device is unable to operate it. Thus, indication locking is considered a very necessary adjunct to all interlocking plants employing electricity or other kinds of power as an operating medium.

WHEN THE INDICATION SHOULD BE EFFECTIVE FOR A SIGNAL. A danger failure of a signal is the term applied when a signal lever has been reversed for the clearing of the signal while the signal is sticking in the stop or danger position. A clear failure is the condition when a signal is sticking clear with the placing of the lever normal. A clear signal failure is the only failure that may be called dangerous and the only kind that indication locking should protect against. That no indication as to the proper operation of a signal is needed with reversal of a lever for the clearing of a signal should be obvious, for the reason that if such a failure should occur the signal would display the stop indication. The need of an indication as to the condition of the signal is only urgent with the placing of the lever in the normal position, because by such a move the release of the switch levers for the route is accomplished and the operator is at liberty to set up an opposing route. Before this can occur it is evident that in order to prevent the operator from displaying a clear signal permitting a certain train movement while at the same time another signal permitting a conflicting movement is sticking clear (a condition which may cause a wreck or derailment or the deviation of a train from its proper course), it must be assured that no two opposing clear signals can be displayed simultaneously.

An indication lock when applied to a signal

(1) Will inform the operator whether or not a signal has responded to a given lever movement and hence assist in detecting an improper clear indication of a signal, or, in other words, prevent a clear failure.

(2) Will prevent the placing of the signal lever upon which it is located at full normal and the consequent unlocking of the switch levers in the route governed by the signal, unless the signal has assumed the stop or, in the case of a distant signal, the caution position.

When the Indication Should be Effective for a Switch. The function of an indication lock when applied to a switch lever must necessarily be to prevent the unlocking of the lever in its normal and reverse positions unless the switch has followed the movement of the lever and has assumed and is locked in a corresponding position.

An indication lock when applied to a switch

(1) Will inform the operator whether a switch has responded to a given lever movement and assumed a position corresponding with the position of the lever by which it is controlled.

(2) Will prevent the clearing of a signal governing train movements over the switch unless the switch is in the proper and locked position, and also prevent the lining up of conflicting routes until it has assumed its safe and proper position.

Development of Electric Indication Locking. The first thought that would occur to anyone attempting to solve the problem of an indication or automatic release of the locking when power is used in the operation of an interlocked unit would be to employ the main source of current used in operating the plant for energizing the indication magnet and have the unit operating mechanism close a controller completing the indication circuit at the proper time. In fact, the first installations ever made had the circuit for the indication lock arranged as shown in Figs. 54 and 55. These diagrams are simplified and all contacts not essential to the principles involved in this indication scheme have been omitted. Fig. 54 shows a signal indication circuit, and it will be noted that the indication lock takes battery at the coils and goes to battery common through a circuit controller, on the signal, closed in the normal position. In this scheme, however, a cross at "X" between the two control wires will cause a false indication, as it will have the same effect as the closing of the indication contact at the signal, and an indication will be produced with the signal at clear. Fig. 55 shows a switch indication circuit, being divested of the apparatus and circuit controllers not directly con-

cerned in the formation of the indication circuits. With the complete reversal of the switch, the circuit closer C, actuated by bar B, which is connected to the switch point or preferably to the lock bar, will bridge contacts D and E and close the reverse indication circuit. This circuit will flow from battery positive through reverse indication lock R, reverse indication wire RI, contact D, C, and E to common. This would permit the final

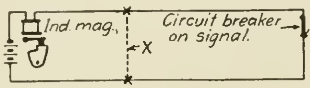


FIG. 54.

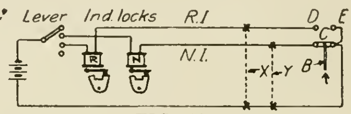


FIG. 55.

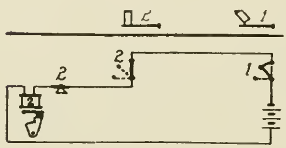


FIG. 56.

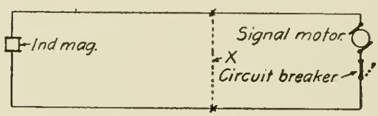


FIG. 57.

movement of the lever to take place. The mere inspection of this diagram will readily display the grave dangers of this scheme. An accidental cross of the RI and common wire at X will have the same effect as the bridging of contacts D and E at the switch. Thus, an indication would be given irrespective of the position of controller C, and consequently irrespective of the position of the switch. Such a cross can in practice easily happen through faulty insulation, and the grounding of either RI or NI wire will have the same effect as the mentioned cross.

Safety and Reliability of Indication. To insure a reliable and adequate indication for an interlocking system it should be observed that:

(a) The power for actuating the indication magnet is procured at the unit operated.

(b) A number of predetermined things should occur in proper sequence in addition to the regular lever movements, and this preferably within a certain time limit, before the indication release is effected.

(c) The effect of a cross or a ground of the indication wire should tend to prevent instead of cause an indication.

(d) In order to prevent two levers operated simultaneously from receiving an indication caused by crossed wires while only one of the functions has performed the operation intended, it should be assured that the current emanating from one function for indication purposes should be subjected to return to that function, thereby hindering the indicating current from taking multiple paths through the devices and cause false indications through a single cross.

INDICATION AT MECHANICAL INTERLOCKING. There are at present two ways in which the indication may be performed for power operated signals at mechanical plants, and these are:—

(1) By Battery indication, and (2) by Dynamic indication.

In the battery indication scheme, the unlocking of the lever is effected either directly by the closing of a contact at the signal with the blade in normal position, thereby completing a circuit which will send current through the indication lock magnet; or, it may also be effected in an indirect way in combination with route, stick or approach locking, in which case the closing of a contact with the blade in the normal position will pick up a stick relay or a signal indicator, and this in turn close a contact which will effect the energization of the indication lock magnet. Fig. 56 shows the battery indication scheme applied to a home and a distant signal, and it is to be noted that the principles are the same as covered in Fig. 54 with this exception: In Fig. 56 the source of indication is carried out to the signal and battery common connected directly at the indication magnet. A cross will here prevent an indication and call the operator's attention to its presence by his inability to complete the stroke of the lever. The lock permits the placing of the lever as far as the normal latching position, so that with the movement of the home lever toward normal the indication current will flow from battery at the signal circuit breaker on distant arm 1, circuit controller on home signal, lever latch, coils of indication lock to battery negative. Thus, in order to energize the indication lock it will be observed that the distant signal must be in the caution and the home signal in the normal position. In order to save current and also to prevent the dangers caused by residual magnetism, the contact controlling the indication lock is only made while the lever is being manipulated. While the purpose of an indication lock is to prevent the

placing of the lever controlling a signal normal while the signal is displaying a clear indication, it is equally important that the lock is so constructed that the leverman is at liberty to place the signal at stop any time if desired, even if the lock should prevent the release of the lever. This is accomplished by the employment of a half reverse lock.

On mechanical signals where circuit controllers are needed for the control of the indication circuit these must be attached so that they are operated by the semaphore arm and not by the up and down rod.

The Proper Placing of the Indication Lock. The distant indication lock is almost invariably placed on the home signal lever on account of the mechanical locking existing between them, except at places where the home signal itself is a power operated signal. In such a case an indication lock is desirable for both signals. Special mechanical locking must then be provided between the levers which will permit the placing of the home and the distant signal levers at their normal latching position, should a failure of the indication lock prevent the distant lever from being released.

Dynamic Indication. With the dynamic indication scheme, the indication is not given by current drawn from the main source of supply which operates the signal, but the indication current is procured by power produced at the signal caused by the backward rotation of the motor, which is effected through the release of a holding circuit when the controlling lever has been placed normal and after the signal is indicating stop.

Fig. 57 illustrates the principles of the dynamic indication scheme as employed for low voltage signals and in which the power for the energization of the indication magnet is developed at the signal. The current is generated by the backward rotation of the motor, and flows to the indication magnet, as shown, and back to the signal motor. A cross at "X" will shunt the indicating magnet and prevent an indication.

Electro-Mechanical Interlocking. In electro-mechanical interlocking (the Post System) the switches are manually operated by a mechanical interlocking lever located in a regular

interlocking frame, and electrically controlled by an electric lever placed above the former. Each mechanical switch throwing lever has a mechanical lock between it and its electric controlling lever, the locking being so arranged that the controlling lever must be thrown to its middle position, thereby effecting the unlocking of the mechanical switch throwing lever, which can then be operated. After the switch lever has been thrown and latched, and after the switch is in a corresponding position and locked, then only can the stroke of the electric lever be completed, which in turn locks the mechanical lever.

A circuit for a switch movement is shown in Fig. 58, and the switch lever partly reversed will unlock the switch throwing

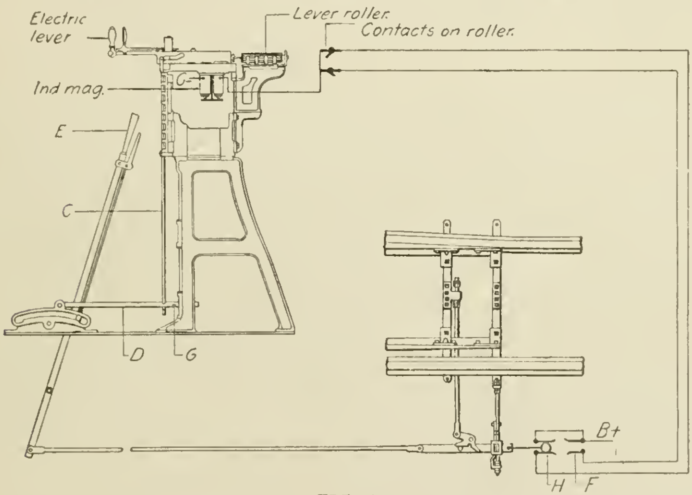


FIG. 58.

lever by the withdrawal of lock rod "C," which rested in a notch in the horizontal rod "D." The reversal of mechanical lever "E" will cause the reversal of the switch, which again will cause the closing of contact "F," thereby completing the reverse indication circuit. Current will flow through contact "F," wire 1, contact on electric lever, wire 2 and indication magnet to battery negative. This will permit the full reversal of the electric lever which, through the lock rod "C," will lock the mechanical lever, the lock rod then entering notch "G." The same operation is performed with the throwing of the switch normal, when contact "H" at the switch will close the normal indication circuit.

Polarized Switch Indication. On railroads where only the most up-to-date developments in signal devices and schemes are installed the check on the position of a switch, as obtained with the use of F. P. L. (see electric bolt lock in Chapter V), is not considered sufficient. Hence schemes have been devised whereby an electric indication of the position of the switch is secured which will give a positive indication that a switch has responded to the lever movement: The reliance formerly placed upon the leverman's judgment as to the integrity of the mechanical connection is therefore made unnecessary. The most reliable and adequate scheme devised for this protection is that obtained with what is generally known as the "SS" relay, which is controlled through the "SS" or the polarized indication circuit.

"SS" Circuit. The "SS" circuit was originally used in connection with electro-pneumatic interlocking, but its features, as applied in present day interlocking practice, have been changed. In "SS" circuits the position of each switch is repeated in the interlocking tower by the use of a polarized relay. This relay should preferably be a specially designed relay of the three-position motor type, which, besides having a normal and reverse position, has the moving armature or member counterweighted so as to return to a center or neutral position with all contacts open, when all current is cut off from its control. The switch circuit controller used for the control of "SS" relays should preferably have a special cam arrangement, designed and adjusted to force the adjustment of the switch circuit controller. The switch circuit controller should also require an adjustment of ¼ inch or less; in other words, the switch circuit controller should necessitate an adjustment to secure the opening of the "SS" circuit when the switch points have moved not over ¼ inch from the stock rail in either position and hold the contacts opened until the switch points have closed to within ¼ inch of the opposite position. Such adjustment of these switch circuit controllers, while not specially required for the control of the three-position "SS" relays, will be found very desirable, as it precludes the possibility of any wrong adjustment of the switch.

Fig. 59 shows the "SS" circuit arrangement for a single switch, "E" being the relay and "F" the switch circuit controller. The

key to the circuit controller adjustment is shown in sketch "A," indicating at what points each contact should make and break through a complete cycle of a switch operation at places where a ¼ inch switch point adjustment is standard. It will be noted that the polarized character of the circuit is obtained by the circuit controller acting as a polechanger, which reverses the current

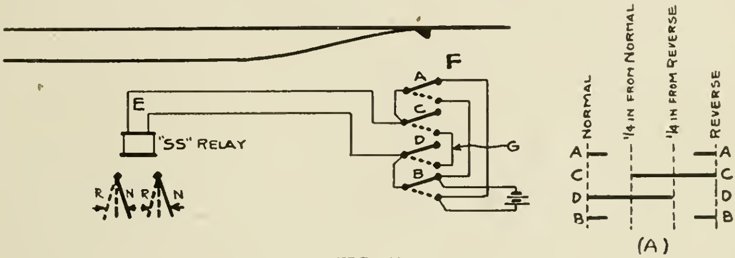


FIG. 59.

through the "SS" relay. These contacts are also arranged so that, when the switch is in transit or is not fully locked at normal and reverse, the two wires leading to the "SS" relay in the tower will be short circuited or placed on a closed circuit by means of wire "G," and the relay will therefore not only be de-energized, but will be absolutely short-circuited. The protection against crosses and false indication, secured not only by this short circuiting feature, but by the polarized character of this scheme of indication and its entire isolation from all other circuits or commons, will be evident.

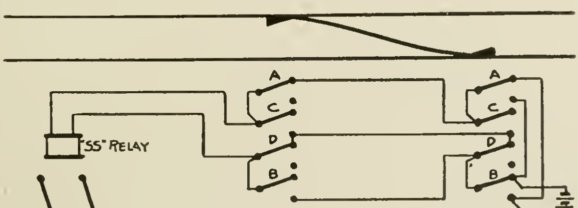


FIG. 60.

Fig. 60 shows how the control and cross-protection of an "SS" circuit for a cross-over can be accomplished by means of only one "SS" relay and a minimum number of wires between the two switches. An indication lock placed on the switch lever and its circuit so arranged that only with the lever in the normal indicating position and the "SS" relay repeating the normal position of

the switch can the lever lock be energized, will give a reliable indication that the switch is in the position corresponding with that of the lever. The same, of course, is true with regard to the reversal of a switch and the circuit Fig. 61 shows the circuit arrangement. The "SS" relays can be used to advantage by accomplishing, within the interlocking tower, the selecting for all the signals. This is called the "SS" control of signals and the control for all is taken through the "SS" relays, as may be required, for every possible route for any given signal.

Switch Indication on F. P. L. Lever. Switch indication can also be procured by placing the lock on the F. P. L. lever for the switch which it locks. The lever lock on the F. P. L. lever

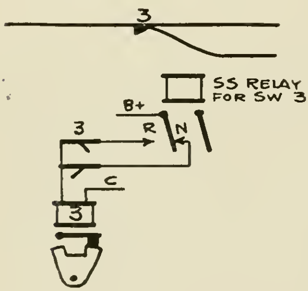


FIG. 61.

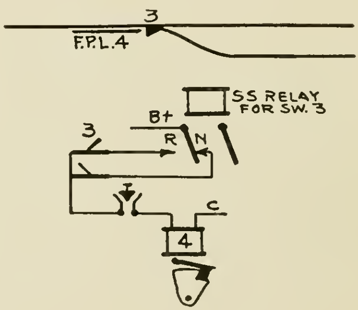


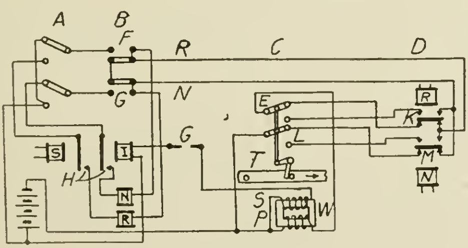
FIG. 62.

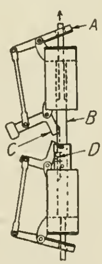
must be a normal lock, which is controlled in the same manner as the switch indication lock. This scheme, shown in Fig. 62, will prevent the reversal of the F. P. L. lever and the consequent release of the signal lever unless the position of the switch and the switch lever correspond. If, instead of the employment of a floor push, a lever circuit controller contact on the F. P. L. lever is desired, the lever lock can be made a half normal lock so that a wider adjustment of the contact can be maintained.

Electric Interlockings. Various sytems for the control of units at an interlocking by power have been developed and there are at present in practical use seven different systems of electric interlockings, representing the production of five principal companies, and each one designed to meet the exact requirements of up-to-date signaling and each one possessing distinctive features

in their mechanical and electrical design and in their indication methods.

AMERICAN ELECTRIC INTERLOCKING. In this system, an induced current for indication is taken from the main operating source but stepped up by an induction coil located at the function. Fig. 63 shows the principles of indication in a switch movement, only such wires as are used in the indication being shown. "A" represents the lever contacts operated through a straight pull of the lever and "B" the contacts operated by a twisting movement of the lever, "C" the controller contacts at the switch, operated in unison with the lock bar "T," and "D" the polechanger movements controlled by the normal pole magnet "N," and reverse pole magnet "R." When a switch is thrown from the reverse to the normal position, contacts "A" will be in the position shown and "F" and "G" will be made. Current will then flow through the primary "P" of the induction coil "W," creating a current of from 300 to 5,000 volts in the secondary, which passes to the spark gap "G," on the interlocking machine, and to common through the indication relay "I," thereby making contacts "H."





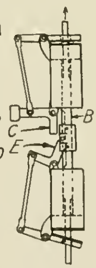


FIG. 63. FIG. 64. FIG. 65.

Current will then flow through the normal indication magnet and stroke completer "N," energizing the indication magnet, releasing the final movement of the lever, and also completing this movement through the stroke completer. This movement breaks contacts "F" and "G." An indication cannot be received while coil "S" (the safety magnet, energized while the function is operated) is taking current, for the reason that it will prevent coil "I" from attracting the armature. Positive battery introduced into the indication wire cannot possibly produce a false indication

since the current, in order to jump across the spark gap, must of necessity be of a higher voltage than that used in the operation of the system, or by any power plant, street railway or lighting system.

Fig. 64 shows the indication and stroke completing devices applied to a switch lever in the normal position. The top coil is the reverse and the bottom coil the normal indication and stroke completer coil. A small coil acts as an indication magnet by attracting the armature "A," and a large coil acts as a stroke completer by attracting the vertical plunger "B." The plunger is attracted upward for a reverse lever movement and downward for a normal movement. Fig. 65 shows the lever held in the reverse indication position. The lever has received the indication and, with the indication latch "C" in this position, is free to be moved from the vertical to the oblique position through the lifting of "B" by the stroke completer coil. It will be noted that the lever when in its normal or reverse indication position is held by the normal and reverse indication latches "C" and "E" engaging the dog "D," which prevents any manipulation of the lever to the right or left.

FEDERAL ELECTRIC INTERLOCKING. In this system the current for the indication is taken from the operating battery source, but is supplied to the indication magnet in such a manner as to insure

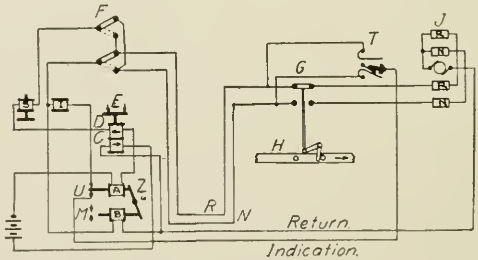


FIG. 66.

absolute safety in indication. Fig. 66 shows the principles used in this system to prevent a false or premature indication. "F" represents the lever contacts and "G" the controller contacts at the switch actuated by bar "H," which works in unison with the lock bar. Safety magnet "S" and indication magnet "I" will lock the lever, should current flow through either one while the

lever is not being manipulated. "E" is a balanced cross-protection magnet comprising a circuit breaker held normally closed while no current is flowing through the coils "D" and "C." These coils are of equal resistance and wound in opposite directions, so that when an equal amount of current flows through both coils simultaneously they will neutralize each other; but should current flow through either coil alone, the armature will be attracted and this will release the main circuit breaker, which is controlled through the contact. The safety relay "Z" has two solenoids, "A" and "B," and plungers whcih are so inter-connected that the operations of one plunger will also affect the other.

Assume the switch to be reversed and the lever to be returned to the position shown. The indicating current will flow through magnets "A," "D" and "S," contact on the lever "F," contact on indicator selector "T" (closed only when the switch is full normal or full reversed and locked in position) indication wire, contact "U," indication magnet "I," and magnets "B" and "C." In the meantime the motor has stopped on the snubbing circuit, and a current will then flow from the motor armature through magnet "B," lever contact, contact on "G" and reverse field winding. This would take place immediately after the running current of the motor was cut off and would bring the motor to a dead stop, and this current flowing though magnet "B" would return the magnet to its normal position, thereby again closing contact "M," when the final release of the lever might be accepted, the indication magnet having been released. In order to receive an indication, several conditions must exist simultaneously and within a certain time. The indication selector "T" must be in the position corresponding with the position of the lever. Contact "U" must be closed by current flowing through magnet "A." This will make it possible to place the lever normal, but the placing of the lever normal will break a lever contact, which is connected in multiple with contact "M," keeping the main circuit breaker on the operating board closed. Therefore, it is necessary that the dynamic current generated through the momentum of the motor energize coil "B," thereby making contact "M." Should this fail, the operating current will be cut off. A cross between "N" and the indication wire can cause a premature indication so far as the completion of the lever movement is concerned, but this would not close "M," and would consequently open the cut-out.

The only remaining chance for a false indication, which might be caused by a positive cross, introduced through a live wire from some other function, is prevented as follows: While the lever is in the reverse position, as indicated in dotted lines on lever contacts "F," the contacts on safety relay "Z" are in the opposite position; that is, contacts "U" are open and contacts "M" closed. The switch in a corresponding position will have the reverse contact on indication selector "T" closed. Hence the indication wire with the lever and switch in the reverse position will be connected with positive battery through magnets "S," "D" and "A" in series. As soon as the lever is placed normal, preparatory to a normal switch movement, the lever contacts will be closed, as shown in Fig. 66. This will immediately connect the indication wire with battery negative, through reverse contact on "T," wire "R," contact "F," and magnets "B" and "C." This is the path

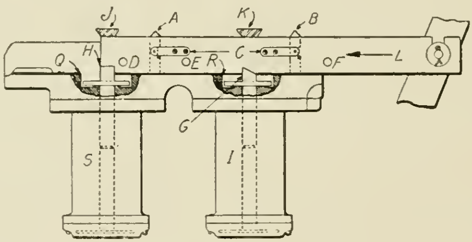


FIG. 67.

which any positive battery from other functions introduced through a cross with the indication wire will take and thereby effect the opening of the main circuit breaker (it will be noted that the introduced current in this case flows through coil "C" only) before the switch movement will have an opportunity to respond to the movement of the lever.

Fig. 67 illustrates the lever and indication parts of the interlocking machine in the normal position. The lock slide "L" carries two square dogs, "A" and "B," which are free to move vertically but held in their raised position by the flat springs "C," through the medium of retaining balls. The locking is effected by the magnet heads "G" and "H" engaging with the pins "D," "E" and "F" on the side of the lock slide. The reversal of the lever will move the lock slide "L" in the direction of the arrow, provided safety magnet head "H" is down so it will pass by pin

"D," when dog "A" will strike plate "J" and dog "B" plate "K," thereby forcing the dogs to their lower position. The dogs will remain in this position and the lock slide can be moved until the dogs engage it with the raised portion of the magnet guide at "Q" and "R," when the lever is stopped until the indication is received. Fig. 68 shows the lever in the indicating position, the

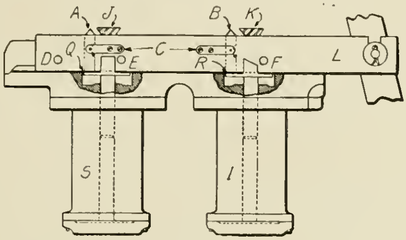


FIG. 68.

indication received and the dogs raised. When the dogs are raised, the lever can be placed in its complete reverse or normal position at any time, the dogs being held raised through retaining balls and springs "C."

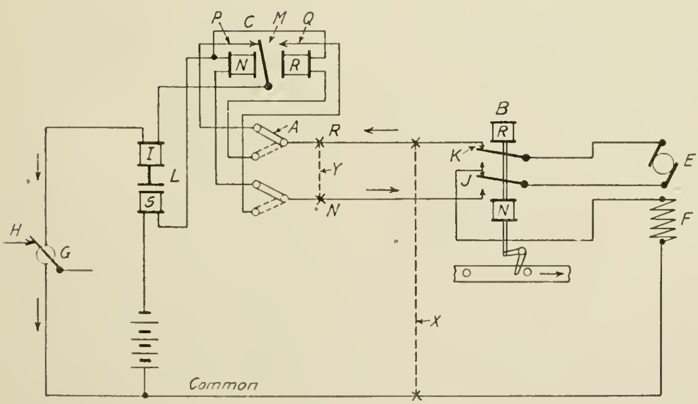


FIG. 69.

The G. R. S. Scheme of Indication. The distinguishing feature of the G R. S. system is the dynamic indication. Dynamic indication means an indication procured at and generated by the motor which operates the function. Fig. 69 shows a switch circuit with only enough of the circuits to illustrate the principles of the indicating scheme and the means employed to prevent a

premature indication. "A" is the lever contacts and "B" the polechanger, which is operated automatically by the lock plunger in the final part of the movement of the switch and during all intervening time under control of the lever by means of the pole-changing magnets "R" and "N." "E" is the switch motor armature and "F" the field. Assume the switch and the lever as being moved from the reverse to the normal position. The switch having completed its movement normal will switch the contacts on the polechanger "B," as shown, with the result that the operating current is cut off the motor circuit. This will also close a circuit through which the momentary current generated by the motor acting as a generator through the momentum acquired will reach the indication magnet. This also acts as a snubbing circuit for the motor. It is obvious that the only effect that a cross between wire "R" and common, as at "X," could have would be to prevent current reaching the indication magnet. If a cross should occur between the live wire "N" and the wire "R," as at "Y," the current thus introduced will flow in the direction of the arrows through the indication magnet and the polarized relay "G" in a direction opposite to the regular indicating current and cause the opening of contact "H," which controls the main circuit breaker. Polarized relay "G" is so constructed that when current flows in a given direction through it, it causes the contact "H" to open, which in turn opens the main cut-out and interrupts the flow of current through the polarized relay as well as all circuits connected with that cut-out. The current introduced through a cross at "Y" could not possibly energize the indication magnet even for a moment, as this current would pass through the safety magnet "S," which would hold the indication armature "L."

To remove the only remaining chance for a false indication, selector "C" is connected in the operating circuit. It comprises two magnets, one in each operating circuit. The lever "M" and the contacts "P" and "Q" form a circuit switch, the function of which is to close the proper indication circuit. If the operating circuit happens to be open and another switch attempts to indicate through the wrong lever (assuming two switches being operated simultaneously), the corresponding indication circuit will not be closed, so it would be impossible for such currents to reach the indication magnet. Should the operating circuit be in

good order and another function indicate through the wrong lever, the indication selector will be in a corresponding position, but the magnet "S" will be energized, as the switch will take current until the movement is completed. The object of the indication selector is also to eliminate any chance for a premature indication should the switch points happen to be blocked so as not to complete their stroke, which condition might cause the motor to revolve backward, due to the opening of the points, thus producing a dynamic current which might have a tendency to cause an indication if the lever is restored to the position from which it started at that particular moment. It will be evident that this also is effectively prevented.

Fig. 70 shows a switch lever in its normal position. When the lever is moved from full normal, the projection "M" on lever "D," coming in contact with projection "K" on latch "L," causes the latch to assume the position shown in Fig. 71, thus bringing

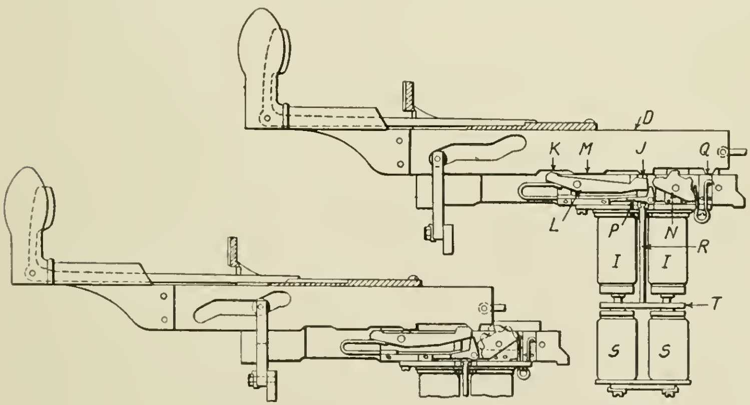


FIG. 71. FIG. 70.

projection "J" into the path of the tooth "Q." In further reversing the lever, the tooth "Q" comes in contact with a similar projection on the cam "N" and causes it to revolve into the horizontal position (shown dotted in Fig. 71), thus forcing dog "P" under and locking "L" in its horizontal position. In moving to the reverse indication position, the cam "N" is revolved into the position shown by full lines (Fig. 71) and the lever is stopped at projection "J," further movement being prevented until the indication current is received. The indication current flowing through magnet "I," thereby lifting armature "T," causes

plunger "R" to strike dog "P" and throw it out from under latch "L." The latch being thus released will resume the position shown in Fig. 70 and permit completing the stroke of the lever. The stroke from normal to reverse is accomplished in the same way.

The Hall Scheme of Indication. In this system an alternating current of 110 volts flows from the tower to the function, where it is stepped up by a transformer to 330 volts of commercial frequency, and the alternating current thus emanating from the function is used for the indication. Fig. 72 shows in a sim-

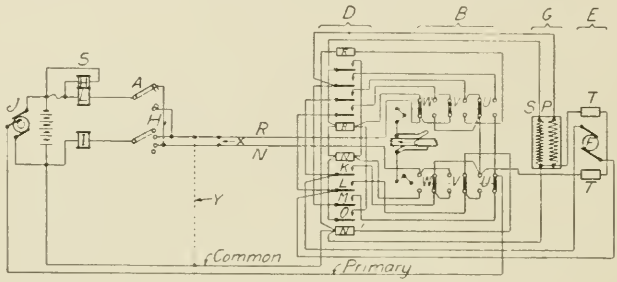


FIG. 72.

plified diagram the principles of the indication scheme with all wires, contacts and apparatus not directly involved eliminated. "A" represents the lever contacts and "B" the controller contacts, actuated by "C," which works in unison with the lock bar. "D" is the indication selector comprising four coils, the two inside of which are connected in multiple with the normal and reverse operating wires respectively, and the two outside coils being controlled by the motor snubbing circuit after the completion of the switch movement. Magnet "S" (safety lock magnet) performs two functions, one of which is to lock the lever in the full normal, full reverse and operating positions, with the safety coil energized; and the other function is to unlock the lever when it has reached the indication position by its being de-energized. It has two windings, one of low ("L") and the other of high ("H") resistance. The high winding is connected in parallel with a fuse, which makes the safety magnet effective with or without the fuse in the circuit. The indication magnet ("I") is immune to direct current or to alternating current of 250 volts

or less. It will therefore be evident that the alternating primary current from the tower (110 volts) will under no circumstances directly operate the indication magnet. Assume the switch reversed and being moved to the normal position, as shown in the figure. With the placing of the lever normal, positive battery flowing over "N" wire will cause the contacts "K," "L," "M" and "O" to make. As soon as the switch has completed its movement, controller "B" will be in the position shown, thereby breaking the normal control circuit. This will de-energize magnet "N" of the indication selector "D," which in turn would break contacts "K," "L," "M" and "O," thereby preventing an indication. The momentum of the motor, however, which with the completion of the movement is placed on a closed circuit, will generate a current which will flow through contacts "K" and "W," field coils "T," magnet "N," contacts "V" and "L" to armature "F." This current, which also acts as a snubbing circuit preventing undue jar to the movement, will energize magnet "N" and maintain the indication circuit closed for a predetermined interval at the selector. The ¼-kw. motor generator "J" (or an a. c. supply from a commercial source), located in the tower whose circuit has been completed through a contactor closed with the manipulation of the lever, will cause alternating current to flow over primary wire contacts "U" and "M," primary coil "P" of transformer "G," back to generator. The current thus induced in the secondary coil "S" of transformer "P" will flow through contact "O," on controller "D," contact "W" on controller "B," lever contact "H" and indication magnet back to the transformer.

This will permit the completion of the lever movement. In the meantime, the switch motor having come to a rest, contacts "K," "L," "M" and "O" will break. It is to be noted that no cross between the "R" and "N" wires, as at "X," can cause a false indication, because the indication magnet would be immune to a direct current; that a cross at "Y" would prevent an indication; also that the indication current emanates from the function and is not existent prior to the movement of the function and cannot be procured through a single break in either indication wire, but being an induced current must flow back to the function from which it was produced. Furthermore, in order to obtain an indication several conditions must simultaneously obtain before the stepped-up current or indication current can reach the indication

magnet. Safety magnet "S" must have taken current; the lever must be in the indication position; controller contacts "B" must be in position corresponding with the position of the lever, and the current generated by the momentum of the motor must hold closed the indication contacts. The indication magnet, being immune to direct-current or alternating current of 250 volts and less, cannot possibly be energized by a cross from either operating or primary current.

Fig. 73 shows a cut sectional view of a switch lever. As a means of preventing the movement of a switch lever to full reverse or full normal position before a proper indication is received, two mechanical locking dogs, "C" and "D," are arranged in each lever slide. These dogs are mechanically forced down by the lugs "F" and "J" into a slot in the bed-plate on which the lever slide "P" rests, and can only be forced out of the slot by

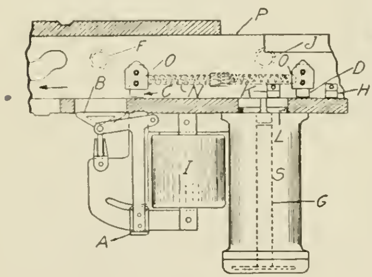


FIG. 73.

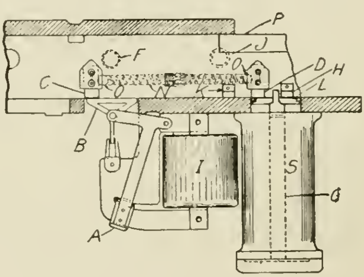


FIG. 74.

the action of the indication magnet "I," which will cause the raising of indication release "B," and by the action of safety magnet "S," which will cause the raising of plunger "G" and armature plate "L." When the lever reaches the indicating position, as shown in Fig. 74, and while the function is taking current, safety magnet "S," connected in series with the operating circuit, will take current and consequently cause the raising of dog "D," which is afterward held by retaining ball "O." After the completion of the movement of the function the indication, being received, will produce an alternating current through the indication coil "I," which repels the copper ring "A," which again operates release "B" and places it in the position shown. This raises the indication dog "C" out of the recess and it is held in position by the retaining spring "N" and the ball "O." The lever

movement can be completed afterward. Should two levers be manipulated simultaneously, one cannot indicate through the other, as the indication coils are in series with their respective transformer secondaries, and the movement of the lever for the function that is not taking current cannot be completed because the "S" magnet will be de-energized. To accomplish the locking of the lever in the full normal and reverse and operating positions with the safety coil energized, two horizontal lugs, "H" and "K," are attached to each lever slide. The armature of the safety magnet has two vertical lugs projecting up from the face of the armature plate "L," which engage the horizontal lugs, "H" and "K." Thus, if the safety coil is taking current before the lever is manipulated or after the indication is received, the lever is locked in these positions. It will be obvious that in order to make a complete lever movement the safety magnet must first be energized and then de-energized, in addition to the energization of the a. c. indication magnet.

The Union A. C. Indication. In this system the indicating current is drawn directly from the main battery, but it is transformed into an alternating current. A convenient means for producing the current used for indication is afforded by a collector ring on the armature shaft of the switch operating motor connected to one segment of the commutator. At the end of the switch movement, after the motor has been disengaged from the mechanism by the clutch, the operating wire is switched from the operating brush to the brush bearing on the collector ring. The

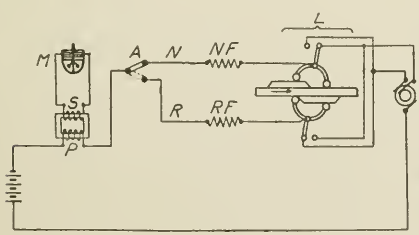


FIG. 75.

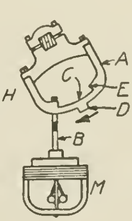


FIG. 76.

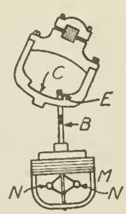


FIG. 77.

motor armature will continue to rotate and, as the segment to which the ring is connected alternately approaches and then recedes from the brush, the current in the circuit including the primary coil of the transformer will in turn generate an alter-

nating current in the secondary coil. The current from the secondary flows through the coils of the induction motor, causing a rapid rotation of the armature, which results in lifting the indication latch. In Fig. 75 the indication scheme is illustrated in a simplified manner, assuming the lever being placed normal and receiving the indication.

It can easily be seen that a connection either accidental or intentional of the wire "N" with any other wire would cause only a direct current to flow through the primary coil of the transformer, which would have no effect on the secondary. As the induction motor is built to require approximately 100 alterations per second to make it operative, it is quite apparent that it could not be affected by any succession of impulses that could be produced by accident. The accidental contact of "N" wire with the wire to any other switch which is in the act of indicating could not result in a false indication because it is in connection with the operating brush of the motor until the movement is completed, which would hold it at a uniform potential either high or low, and would prevent fluctuation.

Fig. 76 shows the indication segment "A" for a switch lever with the lever in its normal position. "B" is the indication latch and "M" the induction motor. The turning of the lever will move the segment "A" in the direction of the arrow, thereby dropping the indication latch "B" into recess "C." Should the latch remain up it would strike dog "D," which would prevent the reversal of the lever and the making of the contacts for reversal of the switch movement. The lever is limited in its movement by the indication latch striking stop "E." Fig. 77 shows the lever in the indicating position and the indication being received. It will be noted that the indication motor "M" has its armature shaft in a vertical position, to which is attached a piece of centrifugal apparatus similar in construction to the governor on a steam engine. The rapid rotation of the armature will separate the weights "N" and lift the indication latch and release the lever.

U. S. & S. Bi-Current Indication. In this system, current is caused to flow towards the positive pole of the operating battery, while at the same time the operating current is flowing in other parts of the circuit. Fig. 78 shows the indication circuit for a switch movement. "A" represents the lever contacts and

"B" the indication apparatus. This apparatus comprises a polarized magnet without permanent magnets, however. The polarization is effected by the operating current passing through one of the magnet coils "K." The other coil "L" must then have current in a certain direction relative to the driving current in order to actuate the latch which releases the lever. To cause current to flow in opposition to the battery is the purpose of the

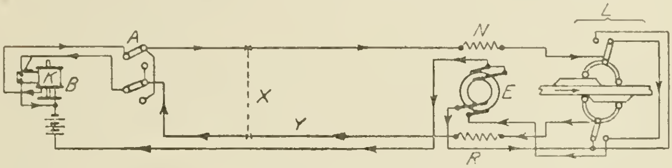


FIG. 78.

two sets of coils on the motor armature of the motor operating each function. This is shown at "E," the outside set of brushes representing the operating armature, and the inner set representing the indication armature. "N" and "R" are the normal and reverse motor field coils, respectively. When the motor is driven through one set of coils on the armature, the counter electromotive force of this set is nearly equal to that of the battery; and since the other set of coils is rotating at the same speed in the same magnetic field, its counter electromotive force is the same as that in the set driving the motor. The result is that a potential nearly double that of the battery is produced at the motor, so that current can be readily caused to flow towards the positive pole of the battery.

It will be assumed that the lever is being placed normal and that the switch movement is just completed. Current will then flow through the operating brushes of armature "E," keeping the motor running idle in the same direction as the last movement of the switch. The current for the energization of the indication coil "L" will flow from the indication armature, through the magnet coil "L," and, as it has twice the voltage of the operating battery, it will operate the indication latch. It will be evident that a cross, as at "X," could not cause a false indication because these connections would have the full positive battery voltage opposing each other. A ground at "Y" would have the same effect. A false indication could not result from the wire being crossed with the indication wire to another switch which was in

the act of indicating, because unless the switch had completed its movement and a change in circuits been made at the motor, the potential would be held down by the motor which had not reached the proper point for indicating.

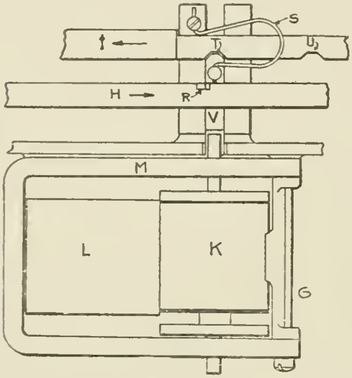


FIG. 79.

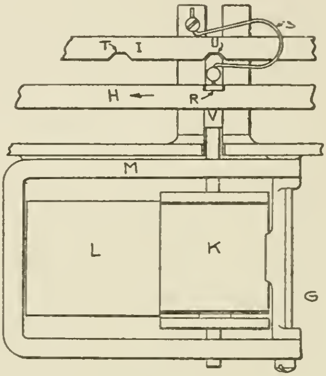


FIG. 80.

Fig. 79 shows the indicating part of a switch lever in the full normal position. The movement of the lever will impart movement to bar "I," and thereby force the indication latch "V" into the notch "R," in this way insuring that the latch is performing its function without entirely depending upon spring "S." Fig. 80 shows the lever in its reverse indication position. Indication latch "V," which rested in notch "R," is lifted by the indication magnet, slot "U" permitting this, and the lever "H" is ready for its final movement. The indication magnet "G" comprises two energizing coils, "K" and "L." The coil "K" is enclosed within an iron tube or shell which forms one pole of a magnet energized by coil "L." The other pole of the magnet resides at the two ends of the yoke "M." Within the coil "K" and free to move in a vertical direction is an iron core having a flat iron disc attached to each end. These discs are the poles of another magnet energized by the coil "K." If the direction of the current in the coil "K" is such as to make the upper disc a north pole and the lower disc a south pole and the direction of the current in the coil "L" is such as to make the shell a north pole and the ends of the yoke south poles, the movable core will be pushed upward; but, if the current in either coil is reversed the core will be held down.

The U. S. & S Type "F" Indication System. Indication is procured through a controller at the switch as shown in Fig. 81, illustrating the principles of a switch indication circuit. Any voltage may be employed in the indication. The circuit is so arranged at the switch indication circuit controller "L" that, should the switch remain in a half-open position, the indication circuit proper is not only broken, but the relay "KR" is placed on a closed circuit through wire "M." The indication is procured through the indication circuit controller "L," performing the function of a polechanger switch, which causes the changing of the polarity of the "KR" relay at the machine. This "KR" relay is typical of the electro-pneumatic and the type "F" electric system, and it can be used to advantage in the control of the signals by selecting the control circuit through the relay instead of

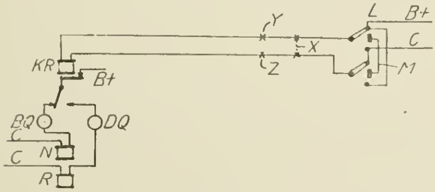


FIG. 81.

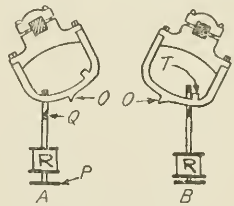


FIG. 82.

the switch boxes, thereby confining the complete selection circuits to the tower. It will be noted that a complete circuit from the switch to the tower and back again must be maintained in order to keep the "KR" relay energized and obtain an indication. A cross at "X" will only prevent an indication. The same is true in regard to a ground at "Y." A positive cross at "Z" will reach common through the indication circuit controller. With the relay "KR" in the position shown, the circuit is made for the normal indication magnet "N" and the reversal of the polarized armature will complete the circuit for the reverse indication magnet "R" through the quick-acting lever contacts "BQ" and "DQ." Should conditions arise, in spite of all precautions described in connection with the indication circuit, tending to produce a premature indication, it will presently be seen that the construction of the indication magnet will prevent the manipulation of the lever so affected.

Fig. 82 shows the indication segment for a reverse indication magnet. "A" shows the position of the segment with the lever

in the full normal position. The lug designated as "O" on the indication segment is instrumental in protecting the system against a premature indication. It will be plainly seen that should the indication armature "P" be held up for any reason, the lower locking surface of the latch "Q" would then engage with lug "O" before the lever had moved far enough to close the contacts controlling the next movement of the switch, thereby preventing the reversal of the lever. "B" shows the indication segment in the reverse indicating position and the latch is shown energized, which will allow the upper locking surface of the latch to clear lug "T" for the final release of the lever. The normal indication segment is of a similar design.

Electro-Pneumatic System. The indication is provided on the battery indication principle and is of a similar design as the Union Switch & Signal Company's style "F" previously described.

Adjuncts. In all types of power interlockings employing various methods of indicating the proper response of a function to the lever movement, it is desirable to apply, in addition to these schemes, the "SS" circuit. With this type of control all signal selection circuits can be confined to the tower, so that during trouble hunting the immediate location of a derangement can be accomplished by inspecting the "SS" relays. As a necessary adjunct to indication locking, many signal departments are at present equipping the semi-automatic signal levers with lights, the control of which being so arranged that they will burn with the signal in a 45 or 90-degree position. This will prevent any delay if the signal is not cleared, as such a condition can readily be discovered.

V

SECTION LOCKING

Definition. Section locking is the term substituted by the Railway Signal Association for the formerly employed nomenclature "detector locking" (also "electric detection") and is defined as being "electric locking effective while a train occupies a given section of a route, and adopted to prevent manipulation of levers that would endanger a train while it is within that section." In section locking, track circuits and relays are used for controlling electric locks on the switch or facing point lock levers, or opening the controlling circuit for switches to prevent their being thrown under passing cars, a function for which detector bars were originally devised. With the use of section locking the track circuits are usually extended to the fouling point of the switch controlled or protected, and it may be employed in lieu of detector bars or in conjunction with them.

The Detector Bar. A detector bar consists of a bar of iron mounted on pivoted links alongside on the outer side of the track rail and so arranged that when moved longitudinally the bar is lifted higher than the top of the rail. The bar is so connected to the switch movement that it must be lifted before the switch is moved. If any pair of wheels is on the rail the bar is prevented from moving by coming in contact with the wheel thread, and it is made of such lengths that it is never entirely free of the wheels of any car standing or moving over it. If the detector bar cannot move, the switch cannot be moved and, consequently, the detector bar will prevent the switch from being thrown under a car.

The Efficiency of the Detector Bar. From the standpoint of safety the inside detector bar—which, contrary to the outside detector bar, comes in contact with the flanges of the wheels—is vastly superior. They are objectionable, however, by reason of the presence of switch rods and other track accessories, which prevent their being placed where they are most needed, and also on account of the wheel flange not being of uniform depth. The introduction of rails larger than 85 lb. section having wide head has lessened the former efficiency of the detector bar, as the bar

when thrown, instead of striking the tread of the wheel, is quite liable to pass up outside. Furthermore, at power interlocking plants, if a detector bar is prevented from being thrown due to the presence of a car moving over the switch, the operation of the switch lever must necessarily injure the detector bar, due to the considerable force transmitted to the switch operating mechanism. In fact, experience has proven detector bars a very uncertain quantity and very unreliable, and it might rightly be said that they are designed on a wrong principle, for the simple reason that, contrary to other signal appliances which are so designed that a failure will give a danger indication, a detector bar when failing is inoperative.

Section Locking Protection. The only check on the manner in which the operator handles his levers at a plant employing detector bars for switch protection is the dog-locking and the detector bar and, with moderate speed of trains and a high intelligence in tower operators, it has proven to be efficient, and nothing more could be desired. Increased speed and the consequent disastrous results which would ensue should the throwing of a switch under a train lead to its partly running off a derail or through a sharp turnout at high speed, has caused the demand for more reliable protection along this line. Thus, to overcome the difficulties and dangers just related and also for other reasons, such as trouble with snow and ice, the track circuit in combination with section locking as a substitute for the detector bar has come into general use. This class of electric locking, inasmuch as it can be used in place of detector bars, can be considered as an economy, because one detector bar can at most be made to protect two switches if they are close together, while one track circuit, with its locks, etc., can displace a number of bars. Therefore, in most cases section locking is not only cheaper to install, but also considerably more economical to maintain.

Combined Protection. Detector bars are often employed in connection with section locking, as there are roads which do not think it entirely safe to depend on the track circuit alone for protection against the throwing of switches and derails under trains, there being numerous instances of conditions where detector bars can hardly be dispensed with. This is particularly true when

guarding against slow acting relays, so as to preclude all possibility of switches being thrown in front of trains on account of track relays not responding quickly when shunted due to sand on rails, rusty rails, poor track circuit or improper relay design. As the safe operation of a switch from careless manipulation while a train is moving over it (where section locking only is provided) is wholly dependent on the quick action of the track relay, it is possible before the lock has responded that at least one of the derails in the route could have been thrown. A plant having no approach or stick-locking should at least maintain one detector bar for the switch at the entrance to each high speed route. At power interlockings the vibration of a fast moving train may also cause the accidental operation of a switch movement sufficiently to unlock it unless detector bars are employed.

For reasons just mentioned and also to act as a check upon the track circuit, many roads in this country are today using both bars and track circuits for switch and derail protection.

Special quick acting relays are frequently employed on very short track sections, such as detector bar sections where, as explained, it is important that the relay respond quickly.

The method generally employed in section locking is to divide the track circuit through the interlocking limits, between the home and dwarf signal into as many convenient sections so as to allow maximum freedom of lever movements and thereby accommodate switching conditions.

At Mechanical Plants. Section locking at a mechanical inter-locking plant is generally applied

(1) By the employment of electric locks on the switch and derail levers controlled through track relays in the sections involved.

(2) By the employment of electric locks on the facing point lock levers that lock the switches in the section and controlled in the same manner as the locks in scheme 1.

Schemes 1 and 2 are alike with respect to the control of the locks, and Fig. 83 shows the application. Lock "D," which, according to the scheme employed, can be applied to either lever 4 or 5, takes battery through the track relay "A" and a lever circuit controller "E." It is evident that as a train is occupying

section "A" the lever is locked in its normal or reverse position. "F" is a screw release often introduced into the circuit to allow the towerman to make a change of route should the track circuit be out of order. There are roads which consider it undesirable to use any release at all where the section locking takes the place of detector bars when bars are not used. They claim that if a release is provided it is possible to operate it while a train is on the track circuit with grave dangers of a derailment. It cannot be denied, however, that even with the most careful maintenance an occasional failure of the track circuit is unavoidable, and in such cases it is a definite advantage that the leverman with his intelligence may act as an immediate substitute for the appliance which has broken down and thereby avoid continuous delay in traffic.

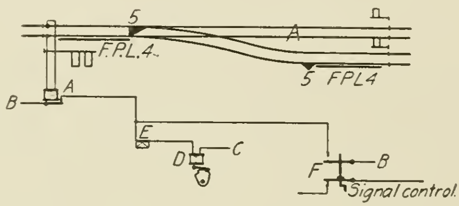


FIG. 83.

With the use of detector bars there will also be occasional break downs and, as this may prevent the change of a route, with consequent congestion and delay to traffic, there is only one remedy, namely, to temporarily have them disconnected. With no release it is necessary to provide a key, placed in a key box, with which the leverman can unlock the lever lock and operate it by hand. With this method, however, the leverman has access to the lever lock until the key is again replaced in the box by the maintainer. (See Chapter XIV).

In order that the operator will again return the release normal, the normal contact on the release should be used for the signal control if the signal is electrically controlled, and if mechanically controlled the release must be an electro-mechanical screw release which when reversed would effect the mechanical locking of all signals governing over the route in their normal positions.

Locks on Facing Point Lock Levers Versus Switch Levers. The employment of full normal and full reverse locks

on facing point lock and derail levers is advocated by some engineers for the reason that it will act as a check on the track circuit, but the practice is not to be recommended because the safe reversal of a facing point lock and derail lever should only depend upon the mechanical locking in the machine and the condition of the switches which they lock, while the protection the lever lock should give is the placing of the lever normal while a train is passing over the functions. Besides the normal position of these levers is an inactive position, as it does not lock nor prevent conflicting routes to be lined up. The practice may furthermore lead to unnecessary delays in case of derangements. The employment of a normal and reverse lock on the F. P. L. lever has the advantage of the additional protection secured thereby. At interlockings semi-automatic signals are given full track circuit and fouling protection, while no such protection is given slow speed and dwarf signals. By having the locking of the F. P. L. lever lock also take effect with the lever at normal, the reversal of this lever and the consequent clearing of any signal is prevented unless the track circuits are in order and all fouling circuits clear of any obstruction.

In a track lay-out one facing point lock lever is often employed to lock several switches, and hence it will prove a more economical arrangement to place the locks on that lever. It should be noted, however, that locks on the facing point lock levers do not give full section locking protection, as it is possible for the operator to line up a route without reversing any lock lever and give the engineman a hand signal or card to proceed, with no protection whatever. It is evident that this could not occur with the locks on the switch and derail levers.

"SS" Circuits. When "SS" relay circuits are employed (see Chapter IV) section locking can be accomplished by placing the lever lock on the F. P. L. lever and the circuit arranged as shown in Fig. 84. With this arrangement indication locking as well as section locking is provided by a very simple circuit arrangement. The F. P. L. lever must be equipped with a normal and reverse lever lock in this case; the normal locking part to provide indication locking for the switch and the reverse locking for section locking protection. Section locking takes place, however, with the normal and reverse position of the F. P. L. lever. If it is

deemed undesirable to have this protection the circuit can be arranged as in Fig. 85, where the F. P. L. lever lock is controlled through the track relay only when the lever is reversed, while the normal control breaks through the "SS" relay only.

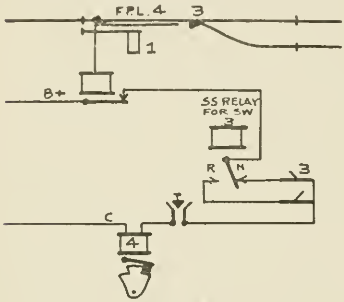


FIG. 84.

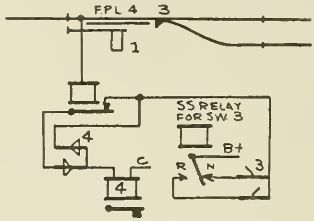


FIG. 85.

At Power Plants. The schemes are as follows:

(1) Protection is obtained by the employment of separate electric locks (in addition to the regular indication lock) on the switch and derail levers and have them controlled as at a mechanical plant.

(2) By the employment of a relay (generally termed lock relay and sometimes lock indicator) which is controlled by the track relay for the section involved and through which is broken the control circuit (the positive side) for the switches and derails in the particular section of track.

(3) A combination of both the above mentioned schemes.

(4) By a modification of the indication lock segment and by having the indication wire in certain positions of the lever controlled through the track relay in the section where a switch or derail is located.

The control of the locks in these schemes is usually accomplished through the medium of an indicator or repeater. This is done in order to give visual indication of the condition of the track section and not compel the operator to depend upon watching the train or trying his levers. Repeated trials will in time wear out the dog and the slot or segment of the lock.

Fig. 86 illustrates scheme 1. The track relay "A" controls the indicator "G," which in turn controls the lever locks for the derails and switches in track section "A." The signal bus bar is cut into as many separate sections as are desirable for proper

operation of the plant and the signal bus feed wire from the operating switch board is broken through a normal contact on the screw release to insure its being restored normal. The circuit may be arranged so that the reversal of the screw release will cause the energization of the indicator, and in many cases this arrangement will prove more satisfactory.

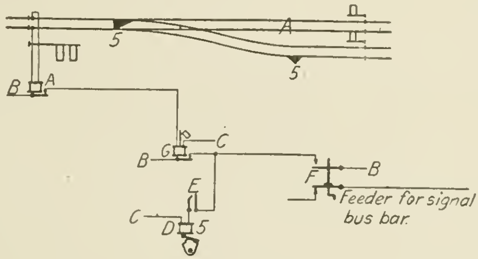


FIG. 86.

Scheme 2 is represented in Fig. 87. The switch bus bar is cut into as many sections as there are track sections at the plant, each bus bar section being controlled through a contact on the track indicator and, if desired, through a closed point on the screw

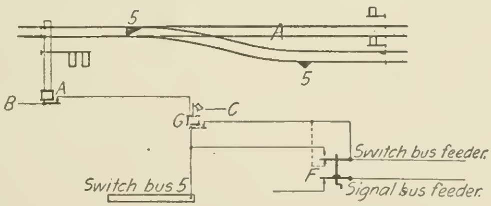


FIG. 87.

release. Thus, this arrangement accomplishes the same purpose as a lock on the lever because the dropping of the indicator will cut current off from the switch, and while not permitting the partial reversal of the lever when a train is on the track circuit, it will prevent the switch from being thrown, owing to the interruption of the current supply.

Lock Relays Versus Lever Locks. Opinions differ as to which one of the schemes described offers the most advantages. There are engineers who have taken the stand that locks on the levers should always be used. Their reasons are numerous.

Cases have been known where the breaking of the switch bus feed circuit was employed, where switches have opened under trains simply because the control circuit on which the integrity of the route depended was open. This may be explained as follows:

In electric interlocking the position of the switch may often depend upon the integrity of the control circuit, because the circuit is so arranged that if a switch should start to open before it can unlock completely the circuit is thrown onto the operating circuit controller, which drives the switch back and puts it in proper position again. If the circuit in such cases was interrupted there would be nothing to prevent the switch point from completely opening, with disastrous results to a train moving over it. Opponents rightfully maintain that if a facing point switch is liable to partly open under a train the result is practically the same, the circuit being interrupted or not. This much may be said, however, in favor of an uninterrupted switch control circuit: Should a train approaching a switch partly open the switch through the vibrations of the track, the switch might be set right again by the aid of an uninterrupted circuit. While the train is on the switch a detector bar will prevent the unlocking of the switch. An occurrence of this kind, which, by the way, fortunately seldom happens, can only be prevented by the use of an electric bolt lock and partly remedied by the use of a detector bar, which must be raised before the switch can be unlocked. Another objection to scheme 2 is the ability of the operator to reverse the switch lever as far as to the reverse indicating position with a train in the section and in distraction leave the lever in this position. Immediately upon the picking up of the indicator current will be applied to the switch and cause its reversal, which may have a disastrous result should a maintainer or a section gang be working at this location. This, of course, is of minor importance and has nothing to do with section locking as a protection to train movements, but it may be typical of some of the points to be considered when choosing a certain style of locking scheme.

With the use of lock relays it has happened that while a switch movement is operated a train or an engine has approached the switch closely enough so as to de-energize the lock relay, thereby preventing the full reversal or the placing of the switch full

normal by cutting the current supply off. This has caused the switch to remain in a middle position, which could not have happened with the use of lever locks. An occurrence of this kind may also cause the arching of the relay points breaking the 110 volt circuit. It is necessary to employ relays having contacts capable of carrying and breaking heavy currents and in some cases a magnetic blow out. Lock relays will also to a certain extent complicate arrangements when used in connection with route locking of a plant where individual locks on the switch levers would greatly simplify the application of the protective circuits. Still another objection to the breaking of the switch control is the possibility of an accidental bridging of the positive signal and switch bus bar, or the liability of the operator attempting to "beat" the section locking with a failure of the track circuit. With the use of lever locks no cutting or separation from other positive busses of the switch bus bars is necessary.

Terminal Protection. Fig. 88 shows section locking as applied to a terminal. To facilitate the handling of trains the track circuit is cut into three sections, "A," "B" and "C." The cutting of the switch bus is performed in the regular way, as explained in connection with Fig. 87, to permit maximum free-

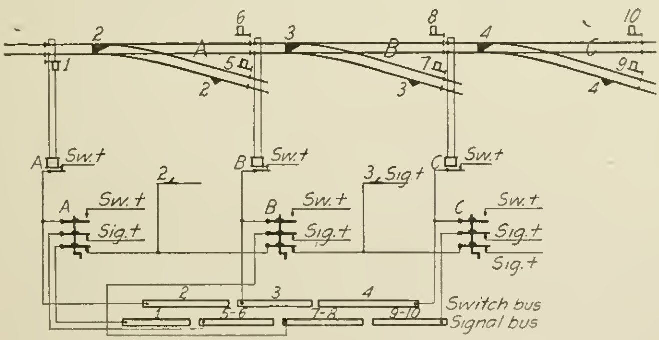


FIG. 88.

dom of lever movements. In order to obtain full protection so that the reversal of the screw release for any one of the sections will prevent the clearing of a signal governing a route lined up over it, unless the release is placed normal again, it has necessitated the selecting of some of the signal bus feed wires. As an example, take signal bus bar 1. Should track relay for section

"C" be inoperative for some reason, the reversal of the screw release "C" will permit the operation of the switch to its desired position. It should be evident that it would not do to have the operator clear signal 1 while switches 2 and 3 were normal and screw release "C" reversed. If signal 1 was not broken through this release with the mentioned line-up of switches, track relay "C" could be shunted out of the switch circuit permanently without interfering with the clearing of signal 1. It should also be evident that with switch 3 reverse, signal 1 should not be controlled through release "C," as this would tie up traffic to some extent. Thus, signal bus bar 1 is broken through all the releases in series, shunted out of release "C" when switch 3 is reversed and out of release "B" when switch 2 is reversed, while it breaks through release "A" all the time. As the other signals only govern one section their bus bars are only broken through one screw release. It should be unnecessary to show a layout employing locks on the levers, as the application will be identically the same.

Combined Protection. The reason for desiring double protection by the use of lock relays and lever locks is first to insure that in case the lock relay should fail to respond quickly the lever lock is depended upon to effect the section locking, and vice versa. Invariably the lock relay and the lever lock should both be controlled through the track relay.

Section Locking for Electro-Pneumatic Plant. Section locking at an electro-pneumatic and style "F" plant is accomplished through the indication magnets. As the two lockings, indication and section locking, are never required at the same time, they can be secured by the use of the same apparatus through a modification of the lock segment, in addition to the circuits controlling the indication magnets. In Fig. 89 the armature "B" of the normal indication magnet engages one side of dog "A" for section locking purposes. With the lever in the extreme normal position as shown the circuit for the section locking starts from positive battery, front contact on the track relay, wire 2, latch contact "C," wire 3, circuit controller "D" and magnet "N" to common, thereby energizing "N" and raising armature "B" from engagement with "A," which unlocks the lever. With the lever in the extreme reverse position current for magnet

"R" must pass through the same relay and controller "D" reversed. The dog "J" engages with the armature of "R" when the lever is reversed in the same manner as "A" with armature at "N" when normal.

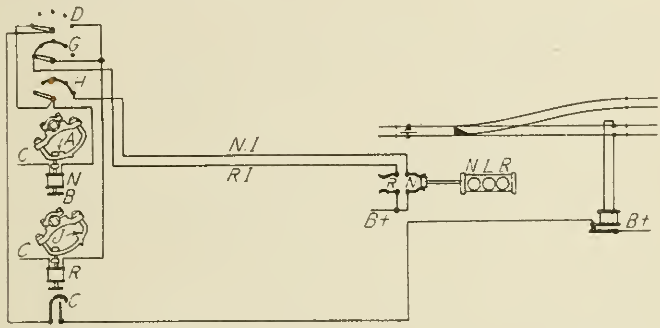


FIG. 89.

Electric Bolt Lock. As an indication for switches at a mechanical interlocking plant the bolt lock is provided, through which the pipe connected signals are controlled to insure the switch being in the proper position for the clearing of the signal. The bolt lock, however, is cumbersome and expensive to apply to any but a few switches in the route, and without the bolt lock dependence must be placed upon the facing point lock altogether with results that may be betrayed in a number of different ways; pins can work out, cranks and compensators work loose from their foundation and the foundations move. The lock rod or plunger or any part of the mechanism can be removed, as in making repairs, and the working of the lever is not affected. In other words, nearly any failure through breakage, removal of a part, or by the reason of lost motion is dangerous and not on the side of safety. In electric interlocking no electric bolt lock is necessary, as a switch must be fully thrown and locked before an indication can be secured at the lever. Here the possibility of vibrations opening the point must be considered, and a bolt lock would prevent this. To make protection complete an electric bolt lock should fulfill the following requirement: The governing signal when clear shall lock the switch in position and the switch, when unlocked, shall place and hold the signal in the stop position. This is accomplished by having an electric lock, situated at the switch, arranged so that when de-energized an armature or

dog drops into a notch in the end of the locking plunger and closes the circuit when raised out of the notch or when dropped below it, due to the absence of the plunger the circuit should be open.

Fig. 90 shows an electric bolt lock circuit as applied to a switch where a mechanical signal governs over it, which will give sec-

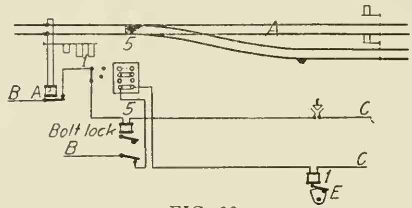


FIG. 90.

tion locking in addition to preventing the operation of the switch while the signal is clear. The signal lever is equipped with a full normal lock "E," which prevents any manipulation of this lever

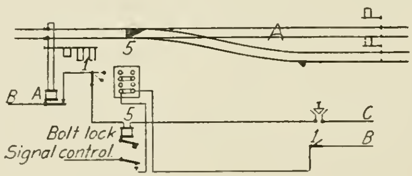


FIG. 91.

while the switch is being operated. Fig. 91 shows the circuit as applied to a power operated signal.

Track Circuit Layouts. From what has been said in the present article and under "The Track Circuit" it should be evident that in a general layout of track circuits it is advisable to have the insulated joints not only located so as to conform to standard practice of the road, but also to have the track sections so related to each other that the best result will be obtained from a track or operating standpoint, and have them so inter-related that the best result will be obtained with a full knowledge of the effects produced for a proper and full protection of such a layout. While this would perhaps be most preferable it is not always practicable, so that the locking and dog sheets should be consulted and, if necessary, revised with the object in view to

avoid undue complications in the track circuit arrangements, and also add to the protection provided by the track circuit, or procure protection where the track circuit should fail to give such.

When designing a track circuit for a certain location it makes a vast difference if the track circuit is provided for the semi-automatic control (slotting control) of the signals, and if it in addition also is used for section locking purposes. Take, for example, Fig. 92, showing a part of an interlocking plant, assum-

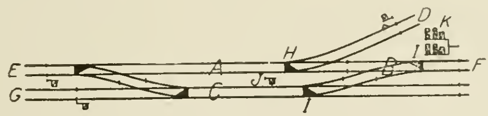


FIG. 92.

ing this to be a plant not employing section locking. It will be necessary to cut the upper track into two track sections "A" and "B" in order that a movement from "D" to "E" will not prevent the clearing of signal "K" for a movement from "F" to "G" over "I" reversed. In other words, to permit parallel train movements to take place, a train standing in section "A" in the rear of the dwarf signal "J" will not interfere with the manipulation of lever for switch "H," no section locking being provided. With section locking the upper track must be divided into three sections, an additional cut opposite dwarf signal "J" being necessary. The necessity of cutting section "A" into two sections is to permit the manipulation of switch lever "H" while a train is standing in the rear of dwarf signal "J," the lever locks or switch buses being controlled through the track relay.

It has been stated that for full section locking protection every particle of track between the home and dwarf signals at an interlocking plant should be provided with track circuits, either in the form of main circuits or fouling circuits. In places where the track circuits are employed for slotting purposes only, fouling protection is equally necessary, but this protection does not necessarily have to be carried as far back as to the dwarf signal. For a proper concerption of this two turnout circuits will be shown.

Fig. 93 shows a turnout provided with a shunt fouling used in connection with a plant not employing section locking. The derail "A" is located at the fouling point and the carrying of the fouling circuit thus far is sufficient. This will be evident for

reasons that for the switch protection the detector bar covers the distance between the signal and the derail. Thus, should an engine proceed past the signal as far as the derail, with the derail normal, it will be derailed, and should it, while the derail is reversed, remain between the derail and the signal, the detector bar will prevent the main switch from being lined up.

A plant employing section locking should have a turnout protection as shown in Fig. 94. Here the fouling protection is carried back to the dwarf signal. While it is not strictly necessary to carry the fouling protection as far as to the dwarf, it is necessary to carry it past the derail for the switch protection. The intervening few feet between the dwarf and the switch are generally included in the circuit as an additional protection when

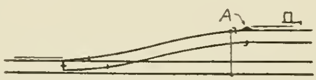


FIG. 93.

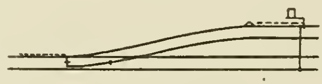


FIG. 94.

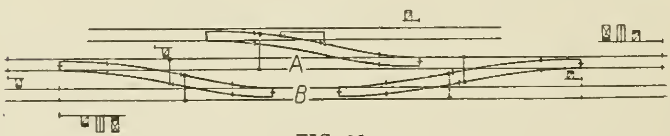


FIG. 95.

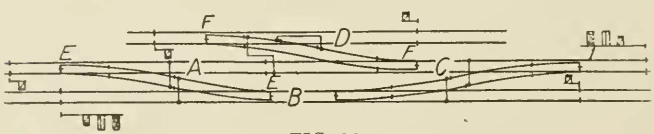


FIG. 96.

section locking only is employed, and as a necessity when section locking in connection with the route locking is employed.

Fig. 95 shows a track layout of two main tracks and a siding, with track circuit applied for signal slotting purposes. The two main tracks each comprise one track section "A" and "B." Fouling protection is provided on crossover between siding and track "A." Fig. 96 shows the same layout when a track circuit used for section locking purposes is applied to it. Here four track sections are necessary, "A" and "C," in order to accommodate parallel movements over crossovers "E" and "F" simultaneously, and "D" is added to provide full section locking protection for crossover "F."

Important Fouling Protection. It should be evident from foregoing examples that four track sections are necessary in the layout Fig. 97. The three main tracks must be operated so as to

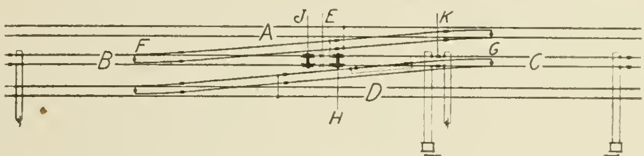


FIG. 97.

allow parallel movements and, in addition, the middle track must be cut between the crossovers to permit trains to pass from track "A" to "B" and from "C" to "D" simultaneously. The solution of the problem would apparently be to place insulated joints in the track at "E," this being equally distant from switch point "F" and "G." These distances, however, are often so short that it would be possible to have a train move from track "A" to "B" with crossover "F" reversed, while an engine or car standing at "H" within the limits of the track section "C" would foul with the crossover. The simplest way to prevent an occurrence of this kind (assuming the joints were placed at "E") would be to have the mechanical locking in the interlocking machine so arranged that when switch "F" is reversed switch "G" would also have to be reversed. In other words, let lever for switch "F" reversed lock lever for switch "G" reversed. Thus, with a car standing at "H" it would not be possible to reverse lever "G," the lock on the lever preventing it, being controlled through the track circuit "C," and consequently it would be impossible to reverse lever "F." Even with this precaution, however, it might be possible to have a car stand at "J" and, reversing switch "G," have a train pass from "G" to "D," sideswiping car "J."

It will be evident that no mechanical lever locking will take care of this condition, because it would be impossible to so arrange the locking that lever "F" reversed would lock lever "G" reversed, and vice versa. There are two ways to overcome the situation, and of these Fig. 97 presents the most simple. Here track circuit "B" is carried as far as practicable toward switch point "G," and track circuit "C" commenced at that point. This arrangement will take care of switch "F" because a train cannot proceed beyond the insulated joints at "K," separating track sec-

tion "B" from "C," without causing the track relay "B" to drop, and consequently either prevent the reversal of this switch, or, if it has already been reversed, cause the signal governing over switch "F" reverse to assume the stop position. In order to protect a movement over switch "G" reverse lever "G" must lock lever "F" reversed.

Another way to take care of the situation would be to have the lock on lever "G," in addition to being controlled through section "C," also controlled through section "B" while switch "F" was normal, and the same in regard to lever lock "F," having it break through section "C" with switch "G" normal. The insulated joints may then be placed at "E." This method, however, cannot be applied to plants where not only section locking, but also sectional route locking is employed.

In Fig. 98 two parallel turnouts are shown crossing main tracks. While the circuits applied to this track layout do not dis-

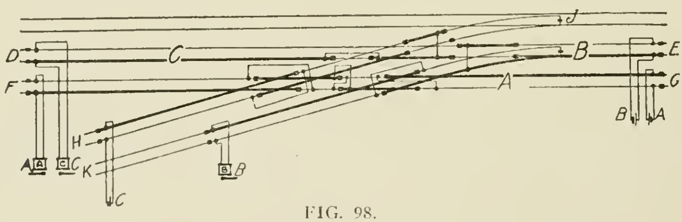


FIG. 98.

play any special features, they do show, however, how a favorable and well protective arrangement can be made of a complex situation with a minimum number of track sections. The present layout is arranged so that parallel train movements can take place from "D" to "E" and from "F" to "G" at the same time, likewise from "H" to "J" and from "K" to "E." It will be noted that track section "A" is carried straight through with jumpers across the crossing rails. Section "C" could have been arranged the same way, but better protection is obtained by the carrying of this circuit to the crossing and then to the end of the turnout. It will be observed that in order to properly arrange the transposition it was necessary to transpose circuit "A" at the center between the two crossings.

Precautions in Designs. When selecting the control of lever locks through levers it should be remembered that never

should the contacts so used be full normal or reverse contacts, for the reason that the lock controlled and consequently also the lever would be dependent upon the proper operation of the function through which it is selected for its manipulation. Thus, should it be desired to have switch 1 in Fig. 99a controlled

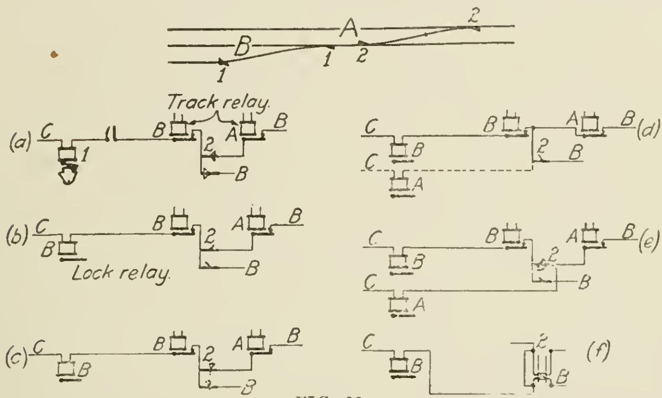


FIG. 99.

through track section "A" when crossover 2 is reversed, contacts closed between the full normal or reverse position and the indication positions should be employed. It is evident that, should switch 2 fail to indicate, thereby leaving lever 2 in the middle position, this should not prevent the operation of switch 1, as it may tie up traffic for a considerable length of time. Of course, the lock on lever 2 is controlled through sections "A" and "B."

A lock relay should never be without current except when the controlling relay is de-energized. This will be evident when referring to Fig. 15a, assuming the same protection to be desired as when lever locks were employed. It would not do to arrange the circuit as shown in Fig. 99b, where lock relays are employed, because it is always possible to manipulate the lever between the normal and reverse indication positions. Furthermore, it is possible to reverse levers 1 and 2 at the same time. Thus, while the leverman may operate lever 1, he may also reverse lever 2. This would cut current off lock relay "B" and in turn off switch 1, which is broken through relay "B," and thereby leave switch in a half reverse position until lever 2 is completely reversed. An occurrence of this kind will also cause the arcing of the contacts breaking the high voltage operating circuit for switch 2.

The circuit shown in Fig. 99c should not be employed (one contact makes before the other breaks) because lever 2, being reversed and with a train in track section "A," it is possible to place lever 2 normal as far as to the normal indicating position, which would thereby shunt out track relay "A," thereby partly removing the protection which was intended.

Fig. 99d shows the correct solution of the problem, and here the lock relay is controlled in series through track relays "A" and "B" and shunted out of relay "B" when lever 2 is full normal. Should it be desired to also use the same contact on track relay "A," an arrangement as shown dotted in Fig. 99d could not be used, as when lever 2 was normal lock relay "A" would be shunted out of track relay "A." Ingenious circuit designers have solved this problem by connecting the circuit as shown in Fig. 99e, one contact to make before the other breaks. This arrangement would be all right as far as lock relay "B" is concerned because lever 2 would have to be full normal before this relay was shunted out of track relay "A." Should lever 2 be left in a position as shown in 99f, it is possible, however, for the operator to circumvent the section locking and release lock relay "A" even with the track relay de-energized, and thus release other switches which may be controlled through the same relay. The sketch 99f shows a different symbol for the lever contacts in order to make the error clear. The only way to prevent this is to use separate relay contacts for each lock relay.

Conclusion. It will be seen from the foregoing that section locking is merely an extension of the function of the track circuit and that proper protection cannot be obtained through a perfect design of the locking circuit itself without a track circuit that is also perfectly designed. It will also be noted that a track circuit only cannot provide adequate fouling protection without the aid of section locking. It will, furthermore, be noted that, while detector bars only protect one switch, section locking covers a track section, which may include several switches, and also that if a detector bar fails it is inoperative, while section locking will prevent any further manipulation of levers and functions. Section locking will also compel respect for dwarf signals and make proper switching movements imperative.

VI

ROUTE LOCKING

Definition. Route locking, as defined by the Railway Signal Association, is "Electric locking taking effect when a train passes a signal and adapted to prevent manipulation of levers that would endanger the train while it is within the limits of the route entered." This definition might easily convey the conception that the protection provided must necessarily include provisions against the throwing of switches and derails under a train while it is moving over them. This, however, is not the case, as many schemes provide protection to a train from the clearing of routes only, permitting other train movements over intersecting tracks—in other words, simply grade crossing protection. Route locking as applied to junction points and terminals, however, is in most cases a development of section locking, being modified to lock all switches and derails in a complete route from the time the train enters until such time as the route is cleared. It will be recalled that section locking provided protection while a train was moving over one track section only.

Purpose of Route Locking. At an interlocking plant where no route locking is provided the possibility always exists that the leverman, before the train has entirely cleared a route, will line up a conflicting or intersecting route for a train movement which may cause a derailment or a collision and a consequent wreck, because there would be no physical check on the leverman which would prevent an occurrence of this kind. The purpose of route locking is, therefore, to prevent such a contingency through the medium of locking devices, either applied to the functions over which the train is moving or to the functions on tracks intersecting the track to be protected. A designer of electric locking circuits should always bear in mind that the protection to be provided should not duplicate or supersede the mechanical dog locking in the interlocking machine. However, it might be applied to advantage as a check on indication locking where power operated units are employed. With this in mind route locking will resolve itself into a very simple proposition.

Route locking proper may be said to contain the basic principles upon which all styles of electric locking are designed. It

might, furthermore, be said that the style of electric locking applicable at different locations varies as to the kind of an interlocking plant to which it is applied. Interlockings are generally installed

(a) For the protection of intersecting tracks, grade crossings and drawbridges.

(b) For the safe and expeditious handling of traffic at junctions for two or more roads.

(c) For the safe and expeditious handling of trains at train-directing or traffic-assorting points, such as yards and terminals.

A combination of the above is often installed, and in these cases the protection must necessarily include the requisite protection combined. Broadly speaking, route locking may be divided into two classes, viz., (a) where it is applied to protect a train from the clearing of conflicting routes, and (b) where it is applied to protect the route occupied by the train.

REQUIREMENTS. (1) Route locking should invariably be made effective with a train entering the first section of a route.

(2) The route may start at the distant, home or dwarf signal, depending upon local conditions and the protection desired.

(3) Route locking can be made effective in one direction on a given piece of track, or in both directions.

(4) Route locking may be made effective with a train entering a route with the signal governing the route at danger (the train being flagged through), or with the signal at clear only.

To simplify diagrams and descriptions all schemes presented will give route locking protection for train movements in one direction only, it being understood that a duplication of this arrangement will give protection for movements in both directions. The track layouts employed to illustrate the various locking schemes are also arranged in the simplest form possible to the purpose, as one switch or signal can serve quite as well as a greater number, which would only tend to complicate an otherwise simple presentation. It is also to be understood that, while a circuit might be shown as applied to a mechanical interlocking plant, the circuit will also answer the purpose for a power interlocking.

Route Locking Protection Only. As previously stated, there are schemes of route locking in which conflicting routes are the only ones locked. That is, while a train has entered one route it accomplishes the locking of the derails, switches or signals of the conflicting routes. This arrangement is used only at railroad grade crossings, but, where interlocked derails with detector bars are employed as crossing protectors, it can hardly be considered any more than additional dog locking, because the detector bars are placed for the purpose of preventing the intersecting route from being cleared while a train is on them. There are places where it is advantageous to employ route locking of the style mentioned and especially where the traffic of one road is small in comparison with that of the other; in many such cases only derails are placed on the road with light traffic and only signals on the road with heavy traffic.

At Non-Interlocked Grade Crossings. At grade crossings between two steam roads or a steam road crossing an electric road, protection is often provided without the means of an interlocking plant. This arrangement is most frequently employed in connection with a grade crossing between a steam and electric road. The requirement is to compel the conductor on the electric car to proceed to the crossing so as to observe if a train is approaching before the route can be set to allow the car to pass over the crossing. As the steam road is to be protected by the route locking, it is also required that the conductor shall not leave the crossing until the apparatus is restored to normal operating conditions. This is the most primitive style of route locking, but very adequate for its purpose, and is illustrated in Fig. 100. "E"

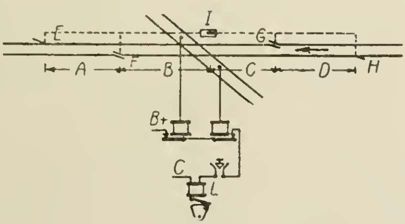


FIG. 100.

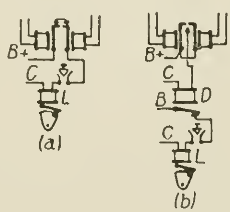


FIG. 101.

and "H" are normally closed derails, while "F" and "G" are normally open derails on the electric road. Distances "A" and

"D" are to be of sufficient length to allow the longest car to stand there, and distances "B" and "C" can be three to four rails in length. The derails are operated from a one-lever stand "I" at the crossing, which makes it necessary for the conductor to go there to observe if a train is approaching before a car is allowed to proceed between derails "G" and "E," assuming the car to be moving in the direction of the arrow. As one lever operates all the derails, the closing of "G" and "F" will, of course, open "E" and "H," so in order that the car can proceed beyond these the lever must again be placed normal. The derail connections are shown dotted. As an extra precaution track circuits can be installed as shown on the steam road, and the full normal lever lock "L" on the switch stand will prevent the conductor from throwing the derails should a train be within the limits of the track circuits. The lever lock is controlled through the track relays in series with a floor push. The length of the track circuit on each side of the crossing will depend upon the usual speed at which trains run at this point, and as a rule 2,500 to 3,000 feet length is sufficient.

Crossing Release Arrangements. Where a separate track circuit is not in service on either side of the crossing, or where two ordinary track relays are employed, a complete movement must be made when a train enters one side of the crossing. Traffic conditions might find the arrangement objectionable, as the traffic on the electric road will be tied up as long as a train remains within the limits of the track circuit. By having the two relays inter-connected or by the employment of a certain style of interlocking relay (see introductory article), as shown in Fig. 101a, the release of the lock will be accomplished upon the train reaching the crossing. The protection arranged on the open circuit principle is shown in Fig. 101b. An open circuit proposition is, of course, always subject to interruptions of a serious nature. Back points are here employed and a lock relay "D" is necessary. The train entering the track circuit on one side of the crossing will pick up relay "D" and, upon reaching the crossing, will again drop it, thereby releasing the lock "L." Any style of interlocking relay can be used with the last arrangement.

Bolt Lock Protection. At a crossing located close to an interlocking and where the traffic does not warrant the expense of

an individual plant, the derails can be bolt-locked and the bolt-locking controlled from the tower. Thus, the towerman must release the derails before the conductor can throw them, which will allow each to test the veracity of the other as to whether a train is approaching; in other words, the responsibility for the safety of the car is placed on both men. As an additional protection, locks controlled through track circuits might be placed on the bolt lock lever.

Route Locking Only at Interlockings. By the employment of interlocked levers at a grade crossing more protection against improper setting up of routes will be obtained. At a crossing, as shown in the previous figure, a three-lever interlocking stand will permit the conductor to stop a train at a home signal. Fig. 102 shows such an arrangement with the levers 1

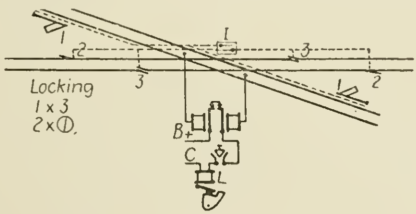


FIG. 102.

and 2 shown as being reversed. The interlocking is arranged so that levers 1 and 2 must be placed normal before 3 can be reversed. Furthermore, lever 3 must be normal and lever 1 reversed before lever 2 can be reversed. This accomplishes the clearing of signal 1 and opening of derail 3 before the conductor can leave the stand. Should a train have passed the signals, the half reverse lock on the signal lever will prevent the lever from being placed full normal, and consequently the integrity of the route is assured until the train has entered the crossing.

Door Lock. There are grade crossings between railroads where the protection of an interlocking plant is desired without the attention of a leverman. As a rule the traffic of one road is small as compared with the other and the route is generally set for the road with heavy traffic. The arrangement is then to permit the trainman to enter the tower, close the door, but before

the change of a route can be accomplished, a lever must first be thrown, which operates a plunger causing the door to become locked. This prevents the exit of the trainman until the original route is again lined up and the levers in their original positions. The door locking lever is generally made to lock the signals on one road in the reverse position.

Stick Release Arrangement. A scheme employed very extensively is shown in Fig. 103. The train occupying track section

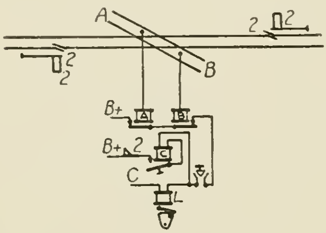


FIG. 103.

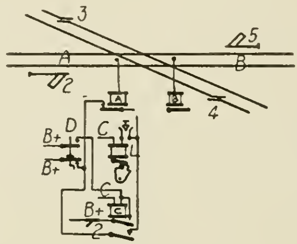


FIG. 104.

"A" or "B" will prevent the reversal of lever 2, which is normally locked. Should a release of the lock be desirable while either track relay is dropped, the raising of the knob attached to armature of relay "C" will energize this relay and keep the armature attracted until the external circuit is broken by the reversal of lever 2. The lock is energized in series with stick relay "C" and its coils will necessarily be of a higher resistance than the coils of the relay. (Lock resistance 30 to 100 ohms and relay 9 to 20 ohms generally proves a good combination.) The employment of relay "C," as shown, is in the place of a time release, and was much in vogue in the early days of electric locking. A drawback is the unsatisfactory operation of the lever lock or locks (a number of locks can be placed in series) when in series with the relay, and also the quick release of the route locking, which tends to encourage hasty action on the part of the operator. Fig. 104 shows a more elaborate arrangement. Signal lever 2 is equipped with a full normal and half reverse lock. The lock is controlled through the track relay on one side of the crossing only, for the reason that as soon as the train has passed the crossing the conflicting route might be cleared. The half reverse part of the lock will permit the lever being placed normal so as to put the signal to danger after a train has passed it, but

to prevent the lever from being placed full normal, which would release the conflicting route. Stick relay "C" is employed should the operator for reasons of interruptions in the track circuit find it necessary to temporarily shunt the track relay out of the lock circuit. The reversal of the hand release "D" will pick up stick relay "C," which will remain energized provided lever 2 is placed in the normal latching position. To make the placing of the release normal obligatory, the lock is controlled through a normally closed contact on the release. As the lock is also a full normal lock, it is evident that the lever cannot again be reversed unless the release is placed normal. The stick relay pick-up wire is broken through a lever contact closed while the lever is in the normal latching position. The latter arrangement is necessary in all cases where a stick relay is employed for emergency release purposes so as to compel the leverman to place the signal at danger before he attempts to release the route by the use of the hand screw release, and also to drop the releasing stick relay so as to restore the plant to normal operating conditions as soon as the release is accomplished. If this was not arranged it would result in the stick relay being permanently energized. It is to be noted that one stick relay can serve the purpose for signals 2 and 5 by having the stick-up wire broken through levers 2 and 5 in series. It is important that these contacts be placed in series, because levers 2 and 5 must be in the normal latching position at one time in order to pick up the stick relay and release the route. It should be noted that in the present track layout lever 2 does not lock lever 5 normal, as both signals are normally at clear.

Where Track Circuits Are Objectionable. In most cases where an electric road crosses a steam road and where crossing protection is desired, the track circuit, if the protection proposed demands one, is always located on the steam road because these roads in most cases have right-of-way preference. There are places, however, where the electric road has this preference and, as the rails are employed for the propulsion current, the track circuit must necessarily be of an alternating current type, and the expense of installing a couple of short track sections would be prohibitive. Fig. 105 shows a simple solution of this problem. The trolley wire or third rail is insulated at "A" and "D," or whichever place the route locking is desired to be effective.

Relay "F" is the lock relay connected across the feeder and trolley wire. A car entering the insulated section of trolley wire will take current through relay "F," which will pick up. The picking up of this relay will prevent the placing of the signal or derail lever lock "L" normal until the car is out of the section. To prevent a too heavy current to flow through the relay a resistance is placed in series and a jumper in multiple with it. The type and size of this resistance will depend upon the voltage of the propulsion current and whether it is d. c. or a. c. This circuit, of course, is obviously susceptible to derangements characteristic of a normally open circuit scheme.

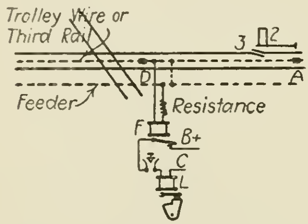


FIG. 105.

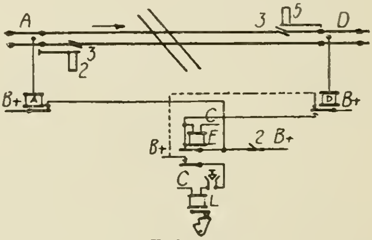


FIG. 106.

Trap Circuits. The locking and release of a route is often accomplished by the means of short track sections or track instruments located where it is desired that the locking and the release take place. The locking section might be located at the distant or home signal and the release section at the crossing or the limits of the interlocking. As a rule a stick relay is employed as a locking medium, but the requirement of route locking, that no route be locked unless the route is accepted by a train, must be adhered to. The superiority of this style of circuit was claimed in the early days of electric locking on account of its reducing as much as possible the number and length of track circuits. As will be seen by referring to Fig. 106 it is a very simple solution of a route locking problem and is often used in the present days of signaling where no track circuit is desired for the semi-automatic control of the signals. "A" is the locking and "D" the release section. A train entering section "A" will drop stick relay "E," which will pick up when the train enters onto section "D." It is obvious that as a train, when entering section "D," will release the locking, the distance between this section and the crossing should be longer than the longest train

expected to traverse the route. Should it be impossible to locate the releasing track section at a distance far enough from the crossing to accommodate long trains, the lock might be controlled through a front point of the track relay, as shown in dotted lines. This insures that not only must a train have reached the releasing circuit in order to release the route, but the train must pass entirely out of it before the levers will be released. By employing a track instrument as a release medium this arrangement is not possible. Particular attention is called to the fact that with a trap circuit so arranged that the locking takes place upon the train entering a route and the releasing after the train is out of the limits of the interlocking, complete route locking is provided and no throwing of switches and derails under a train is possible. It cannot be considered as safe as section locking combined with route locking, because dependence is solely placed upon the integrity of the stick relay circuit and that this relay will operate in accordance with the action of the apparatus acting as a locking medium. The contact on signal lever 2 is inserted so that a train moving in a direction opposite to the one governed by signal 2 will not drop the stick relay when entering section "A." This means, of course, that the route locking will be effective only when the train enters the locking section with the signal at clear. By arranging the circuit as

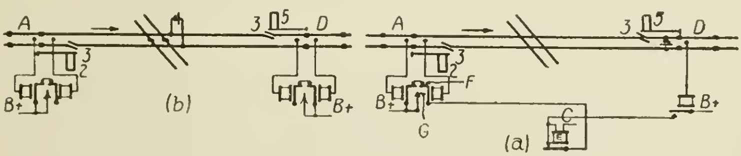


FIG. 107.

shown in Fig. 107a, where an interlocking relay of the style indicated in the symbol is used, it is possible to eliminate the signal contact shunt. Here, in addition to the regular two front points, a back point "G" is employed, which will keep the stick relay energized when trains run in the opposite direction to the arrow. With this arrangement the stick relay should be slow acting so as not to drop during the time interval when front point "F" breaks and back point "G" makes. Back point "G" will not influence the circuit when a train, running in the direction of the arrow, enters section "A." Another stick relay can be employed

for opposite movements and the lock broken in series through a point on both stick relays. Fig. 107b shows the track circuit as arranged with the locking and release sections on both ends of the interlocking arranged to accomplish the route locking without the employment of signal contact shunts. This is a center-fed track circuit, often employed to good advantage.

Crossing Lever. If a grade crossing is protected by an interlocking plant and complete derail and signal protection provided, route locking protection can be obtained at a nominal cost by the use of a crossing lever and certain modifications of the mechanical locking in the interlocking machine. A crossing lever is a separate lever in an interlocking machine, so designated because the locking between it and the other levers protecting the crossing is arranged so that no conflicting routes can be lined up and cleared for another train until the crossing lever is released by an unoccupied track circuit or a released route. An example of its application is shown in Fig. 108. With the mechanical

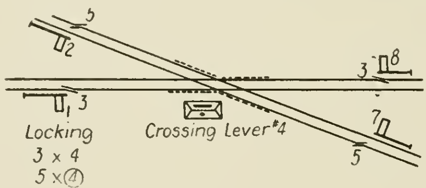
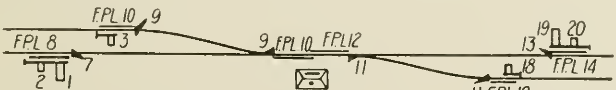


FIG. 108.

locking arranged as shown, a rule can be laid down to cover a more complicated layout, viz.: All switch and derail levers or F. P. L. levers on one road should lock the crossing lever normal, and all switch and derail and F. P. L. levers on the other road should lock the crossing lever reversed. By controlling a full normal and reverse lock on the crossing lever through some route locking medium the levers controlling a movement over the crossing cannot be reversed. Formerly this protection was very incompletely obtained by the means of crossing bars located at the crossing, as shown in dotted lines. It is to be noted that with the use of a crossing lever no protection from the throwing of switches or derails under a train is provided.

Route Lever. Route levers, while very popular in Europe, have never become so in the United States until lately, when it

was realized that it often offers a very simple solution to an otherwise complicated route locking problem. In Europe it has been considered an essential operating requirement that an interlocking plant should permit of any possible route and combination of switches being given so as to cover irregular movements and emergencies. Each route or movement was protected by a route lever in addition to the signal lever. In the United States route levers proper are seldom employed, but certain levers are functioned as route levers (often called a key lever, master lever and occasionally a lock lever). The advantage of a route lever in connection with route locking will be evident when it is considered that by using one lever as a key lever and so arrange the locking that it will lock all other levers in the route, the placing of a lock on this lever will make it unnecessary to equip the levers locked by it with lever locks. The lever chosen to perform the function of a key lever is generally an F. P. L. lever, where such are employed; at other places a switch or preferably derail lever is used for this purpose. It is not advisable to use a signal lever as a route lever because it is always possible to have a train proceed under a hand signal or caution card, in which case no route locking would be provided. The use of a switch or F. P. L. lever may often work a hardship on the operator at a large mechanical interlocking plant for the reason that the lever so employed will always have to be placed normal before another line-up can be made.



(a)

15	10 - 12
	w 9 x 8
	w 11 x 14
15	Full reverse lever lock

(b)

10	9 or 9 - 12
	w 11 x 14
	w 9 x 8
10	Full reverse lever lock

(c)

7	9 - 11 or 11
	w 11 x 13
9	11 or 11
	w 11 x 13
7	Full reverse lever lock
9	Full reverse lever lock
Hand release	1 - 2 - 3 - 18 - 19
	20 Releases 7 - 9

(d)

FIG. 109.

At Junctions or Train Assorting Interlockings. The advantage of the use of a route lever will be most apparent at a junction, of which a simple layout is presented in Fig. 109a. On

this layout a separate route lever might be employed which will mechanically lock all the levers in the route, or rather the functions which are locking other functions. The signal levers must not be locked by the route lever, as it should be possible to put the signal levers normal at any time irrespective of the position or locking of the route lever. Assuming lever 15 employed as a route lever, the locking for this lever should be arranged as in Fig. 109b. All the signal levers should lock lever 15 reversed. If a separate route lever is objectionable a lever can be chosen which must be thrown for any line-up of switches. This would be an F. P. L. lever and should either be lever 10 or lever 12. Assuming the use of lever 10, this lever should lock all other lock levers normal or reversed, as shown in Fig. 109c. It is to be noted that in order to clear any route lever 10 must first be placed normal, and for a large interlocking plant this might be objectionable.

Pros and Cons About Route Levers. The advantage of the use of a separate lever or an F. P. L. lever as a route lever is the reduced number of lever locks necessary, and also that it will prevent the operator from reversing these levers while the route is locked. Should the lock be placed on other levers it will be possible for the operator to restore the F. P. L. lever normal, which would leave the switches and derails unlocked with perhaps dire results if vibrations of passing trains should cause them to partly open while a train is moving over them. The disadvantage of the arrangement is that the operator, by the use of a hand signal, can permit the train to proceed without the reversal of either the F. P. L. levers or the route levers, thereby leaving the train without protection. By the use of derail levers this disadvantage is not present, but additional lever locks are required. In the present layout two locks will be necessary, one on lever 7 and another on lever 9, and the locking will be arranged as in Fig. 109d. A route lever locking arrangement is contrary to a crossing lever, because a crossing lever will protect conflicting routes, while a route lever will protect the route occupied by the train. The circuit for the route lever lock can be designed to suit local conditions. If protection is provided by the use of a trap circuit, as shown in Fig. 106, it will be necessary to arrange the locking circuit as shown in Fig. 110a, and

select the locking circuit on lever 9 and the pick-up circuit on lever 11. It is to be understood that this circuit covers movements in one direction only. The selecting arrangement is necessary so that a train standing in section "C" will not release the route for a train movement from "A" to "B."

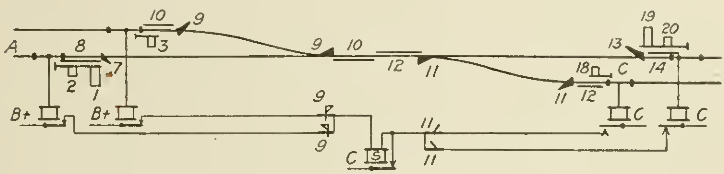


FIG. 110a.

With regard to this circuit it should be evident that a shunt on the normal signal lever contact is in many cases necessary, as described in connection with Fig. 106, so that the stick relay will not drop with a train movement from "B" to "A." Where locks on signal levers are employed such shunts are not absolutely necessary, as the dropping of the stick relay will not prevent the clearing of the signals. The circuit is designed on the selective circuit principle, but it can also be arranged on the shunt principle, as shown in Fig. 110b, no selection on switch 9 being necessary. The trap circuits shown in Figs. 106 and 110 are not the most desirable for electric locking purposes, but are shown because they more clearly illustrate the principles involved in this discussion. It is evident that they may be substituted to advantage by any of the trap circuits described in Chapter III.

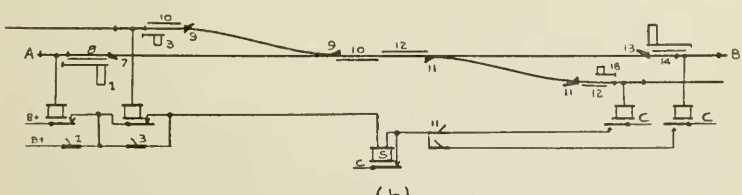


FIG. 110b.

Emergency Release. Very few examples have been given in the present article concerning emergency releases. It is obvious, however, that the releasing devices shown are not the only means which can be employed, or that they are the most desirable

in the circuit to which applied. There are a great variety of releasing circuits and devices that might be used. Where such are purely electrical devices the circuits and symbols should be shown on the wiring diagram; where they are of a mechanical origin reference is made to their employment on the dog and locking sheet. With a mechanical hand release the mechanical unlocking of the lever lock must cause the mechanical locking of the signal levers governing over the route to be unlocked. With an electro-mechanical hand release the arrangement is that its reversal will close a circuit for the energization of the lever lock to be released, while at the same time the signal levers in the route are locked normal mechanically. Fig. 109d shows how reference is made to this effect on the locking sheet, and Fig. 111a shows in condensed form how the dog sheet refers to it.

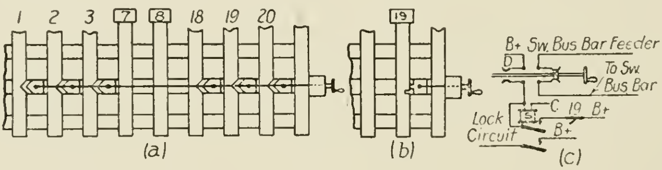


FIG. 111.

The cutting of the electric lock segment should be shown in the circuit plan and also the arrangement of the circuits for its release if used in connection with an electro-mechanical hand release. Another arrangement showing the application of an electro-mechanical hand release is illustrated in Fig. 111b. Here the lever lock is assumed to be placed on the signal lever and, to insure a more positive dog lock, the shape of the dog is made square. Before the signal lever lock is released the signal lever is put normal to its indicating position in order that the hand release may be reversed. This also insures that no switch lever is released until the release is again placed normal. The release circuit can be arranged as shown in Fig. 111c. The reversal of the release will close contact "D," thereby energizing stick relay "S," which will stay up until the signal lever is placed full normal. The lever lock is controlled through the front point of this relay and a normal contact on the hand release might be used to control the switch bus bar or switch lever locks if employed in connection with an electric interlocking.

Combined Route and Indication Locking. For low voltage controlled signals at mechanical interlocking plants it is not only advisable but vital that some indication locking protection be provided. This can readily be accomplished in conjunction with route locking, an example of which is illustrated in Fig. 112. By always controlling the lever lock through normally closed circuit controllers on the signals (distant, home, dwarf or all of them in series) indication locking is provided for these signals. The lock must also be controlled through a locking section which might either be the track section between the distant and home, or the home and crossing (section "B"), or both. Under normal operating conditions the locks in Fig. 112 are controlled through the circuit controllers 1 and 2 on signals,

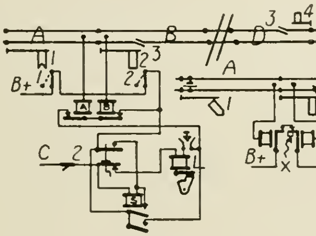


FIG. 112.

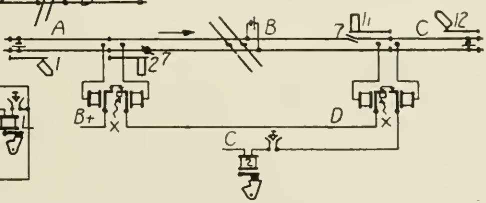


FIG. 113.

track relays "A" and "B," lock coil "L," floor push and a circuit controller on the signal lever. The reason for the employment of a contact on the signal lever has been discussed. If track conditions require the release of the route, the reversal of the hand release will energize the stick relay "E" through the reverse contact on the release. The stick relay will remain energized through its own front point, but before the lever lock can be energized, the release must be put normal again.

Combined Route and Section Locking. In order to combine the route and section locking (by many roads considered as the only proper route locking) the locks must be controlled through all the track relays in the route to be protected. A simple scheme of this kind for a single track road is shown in Fig. 113, where route locking is provided for movements in both directions. A train moving in the direction of the arrow will, when entering onto section "A," cut current off the lock and by

equipping one back point of the interlocking relay with bone insulator, as shown at "X," the route will be locked until section "C" is reached, when current is again applied to the lock. A train moving in the opposite direction will release the lock when entering section "A." By breaking wire "D" through controllers on the signals in series (if desired also signals on the intersecting road) indication locking in addition to section and route locking will be provided. It should be evident that in all previous examples section locking will be provided in addition to the route locking by controlling the lever locks through the track relays in the route.

Deficient Indication Locking. The impression prevails that indication locking is provided for the interlocking when the circuit for a lever lock is broken through signal circuit controllers closed when the blade is at 0 deg. This is not true, because if a lock is placed on a switch derail or F. P. L. lever, while it is not possible to put this lever normal to change a route, it is possible to put one signal lever normal and clear an opposing signal while the first signal is sticking clear. For this reason complete indication locking can only be provided by placing the lock on the signal lever.

"SS" Circuits. Where "SS" relay circuits are employed any combination of indication, section and route locking protection can be procured by the arrangement of the circuits, as shown in Fig. 114. With this arrangement, when the F. P. L. lever is

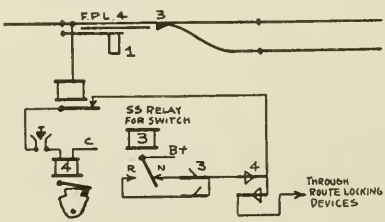


FIG. 114.

normal the switch indication protection takes effect, whereas with the lever reversed any type of route, approach or stick locking can be made effective with the application of the desired circuit. It will be noted that section locking is in effect at all times.

Terminal Route Locking Applications. At interlocking plants where complete section locking protection is provided a route locking problem can be very simply solved by the employment of half reverse locks on the signal levers, which are controlled in series through all the track sections governed by the signal. Should the signal govern over more than one route the lock control will necessarily be selected with the different line-up of switches. Where locks on the switch levers are employed for route locking purposes the circuit will become somewhat complicated when used in connection with an interlocking where the routing of each signal extends over a number of combinations of track sections. Figure 115a shows a simple layout of

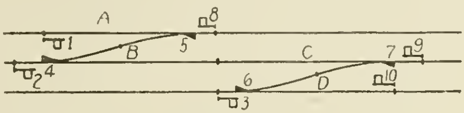


FIG. 115a.

this kind. It will be observed that in Fig. 115b a selective scheme is employed so that with certain line-up the switch lever locks

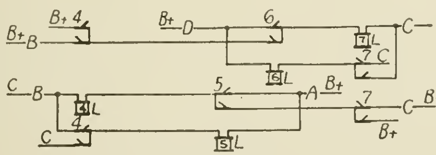


FIG. 115b.

are controlled through more than one track section. For the sake of simplification each front contact on a track relay is indicated with the letter for the track section by which the relay is controlled. For example, lock 7 takes battery through a front point of track relay "D" when lever 6 is reversed, and when levers 6 and 4 are normal it takes battery through track relay "B." Lock 7 goes to common through front point on track relay "C." The cross-protection rules have not been followed here, as a clearer comprehension of the route locking principles will be obtained with the circuit simplified, as shown. Should release be desired the scheme described in the section locking article would have to be followed. When a layout is not too complex a very good arrangement is possible with the shunting method.

In this scheme (Fig. 115c) the lever locks are controlled in series through track relays and shunted out when certain switch levers are reversed, thereby making the operation of the lock independent of a train movement over the sections which are shunted out.

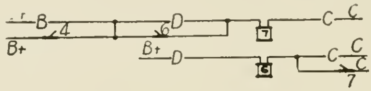


FIG. 115c.

Taking lock 6 as an example, its circuit in the latter scheme cannot be combined with circuit for lock 7 through relay "C."

Another simple terminal layout is shown in Fig. 116a. "A," "B," "C," "D," "E," "F" and "G" are track sections within the interlocking limits. The locking circuit for switch 3 will, by the

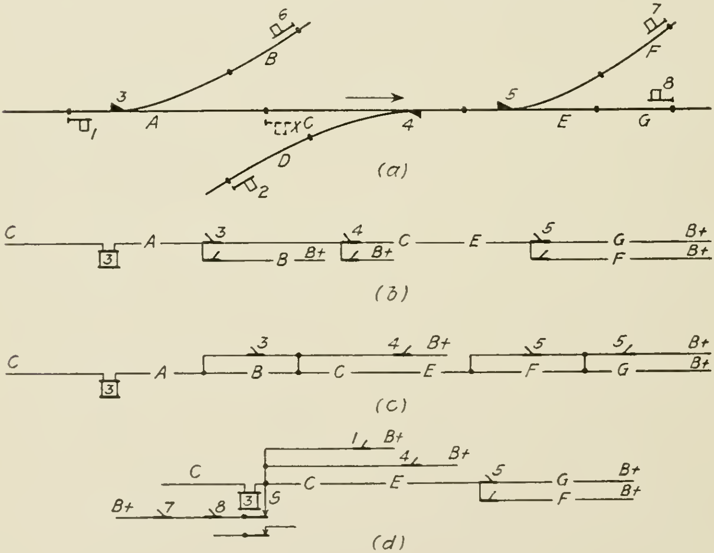


FIG. 116.

use of a selective scheme, be arranged as shown in Fig. 116b, and by a shunt scheme as in 116c. Attention will be called to the fact that the selecting contacts on lever 3 in Fig. 116b must be adjusted to make past the locking point on both the normal and reverse sides in order that the lock may be energized past these points while changing the lever from normal to reverse, and vice versa, where lever locks are employed for locking

purposes. This, of course, would apply to all selecting contacts where lever locks are controlled in a similar manner. Where lock relays are employed the contacts should make at the full normal and reverse position of the lever, for reasons as given in Chapter V. The normal contact on lever 4, while not absolutely necessary, as the circuit will operate practically the same without it, is shown in order to more clearly bring out the difference between the selective scheme, which this is, and the shunting scheme of circuit control shown in Fig. 116c. The contact is also provided since many railroads find it advisable to separate the various selections when hunting trouble and also because it is necessary to employ this contact if switches are located in Section D for wires controlling these.

Assuming signal X to be added to this layout, there will be three routes between signals 1 and 8—one route from 1 to X, one from X to 8, and one from 8 to 1. As route locking should only accomplish the locking of one route at a time, it is evident that a train moving in the direction of the arrow should lock section A only as it passes signal 1; sections C, E, and G only after it passes signal X, while the route for signal 1 (section A) is released after the train passes out of that route. Hence, switch 3 should be locked only while section A is occupied when a train moves in the direction of the arrow, but when trains move in the opposite direction 3 should be locked from the time a train enters the route until it has passed out of section A. A stick relay is necessary, and the circuit, Fig. 116 (d), will be one way to solve the problem. With lever 1 reversed, the stick relay will remain energized. The same applies when switch 4 is reversed. If switch 4 is normal and a train enters section F or G with signal 7 or 8 clear the stick relay will drop and stay de-energized until the train passes signal X. In this way the stick relay will take care of the overlap locking necessitated by the addition of signal X. The lock on lever 3 or the lock relay for section A will break through this relay in addition to breaking through track relay for section A. The lock should of course also break through section B so as to provide protection after a train has passed signal 6.

At Power Interlockings. It is to be understood that the schemes presented can be used at power interlockings as well as

mechanical plants; that is, all levers might be locked direct. Instead of lever locks it is possible to interrupt the control circuit for switches and signals while a train is occupying the route or a conflicting route by the use of lock relays. Thus in Figs. 15 and 16 the lever locks might be substituted with lock relays through which the switch control circuits are broken, or, for that matter, the bus bar feed wires proper might be selected without the use of lock relays. When arranging the circuits proper care should be taken, as outlined in "Section Locking" that the current supply is not cut off from any lock relay or bus bar while manipulating a lever through which the route locking is selected. There being no F. P. L. levers at a power plant the possibility of obtaining route locking through the medium of these levers is eliminated. In some systems it is possible to break the indicating circuits or indication wire through the relays which are employed for locking purposes. If the indication circuit is broken it is evident that the lever controlled is locked in an intermediate position and the integrity of the route assured. There are electric interlocking systems where the breaking of the indication wire is not possible. This will be apparent when consulting the indication locking schemes previously discussed in this series.

Rules with Regard to Lever Locks. In addition to what was related under "Section Locking" the following may be said with reference to the application of lever locks and their advantages and disadvantages in all styles of electric locking. When route locking is desired for the route occupied the lock, if placed on the signal lever, should be a half reverse lock, which permits the placing of the level normal as far as to the indicating position but not the complete release of the lever. The advantage is that only one lock is required per route, and the disadvantage that route locking is not provided except by a train movement under a clear signal. The lock, if placed on an F. P. L. lever should be a full reverse lock. This arrangement will also reduce the number of lever locks at a plant but is subject to the objection just related, as by means of a hand signal the train might be given the right-of-way without the reversal of the F. P. L. lever. Locks on derail levers should be full reverse and locks on switch levers full normal and full reverse. As no route can be set up without the manipulation of derails and switch levers it is the most re-

liable protection. However, it will not protect against the placing of an F. P. L. lever normal, which will cause the unlocking of the switches and derails while a train is occupying the route. At places where the conflicting routes only are locked a full normal lock on the signal lever will protect against the clearing of the signal. A full normal lock on the F. P. L. lock lever will prevent the reversal of this lever, but in both cases no protection is given against train movements under a hand signal. A full normal lock on the derail lever will give absolute protection. Since the derails and the switches are situated on the conflicting route, the objections just related regarding the unlocking of the switches and derails where the route locking is applied to the route occupied by a train do not obtain here. Complete indication locking is not possible without the locks being placed on the signal levers and complete section locking only with the use of locks on the switches and derail levers or where a switch or derail lever is employed as a route lever.

Conclusion. A circuit designer should always bear in mind that when designing a route locking circuit the most complete protection obtainable should be provided with the simplest and, consequently, most economical wiring arrangement. In the various schemes presented herein it is to be noted that, while they provide adequate protection to suit various conditions, they could in many cases be supplanted with additional protection by very little additional wiring and thereby provide protection which will greatly benefit the safe operation of the interlocking. In other words, plain route locking can readily be arranged in combination with other styles of electric locking so as to provide more complete protection at a small additional expense.

VII

STICK LOCKING

Definition. Stick locking is defined by the Railway Signal Association as being: "Electric locking taking effect upon the setting of a signal for a train to proceed, released by a passing train and adapted to prevent the manipulation of levers that would endanger an approaching train." In other words, stick locking is so designed that the setting of the signal will cause the locking of the route to take effect. It derives its name from the manner in which the locking is effected and also because a stick relay is usually an element of this style of locking.

Inception of Stick Locking. In "Section Locking" various reasons were set forth why many railroads found detector bars deficient as a protective medium and therefore looked around for means whereby they could be entirely dispensed with. Track circuits were found to be a reliable substitute but the trouble experienced with slow acting track relays which were apt to remain energized until the train had reached the first derail or switch in the route was a common occurrence. To overcome this difficulty was one of the reasons for the development of stick and approach locking. Furthermore, speed increased to such an extent that distant signal indications had to be given farther away; and as increased speed means more space in which to stop it follows that the disastrous effects of a collision or a derailment would be vastly increased should a clear distant indication be taken away from the engineman.

Requirements. 1. Stick locking should be made effective (a) with the clearing of a signal, or (b) with the reversal of the signal lever (home, distant or dwarf signal) governing the route to be locked.

2. The release of the locking should be made effective (a) with the restoral of the lever after the expiration of a certain time interval and (b) with the train having entered a certain circuit controlling stock section or actuated track device.

3. Stick locking can be arranged so that the restoral of the signal lever normal at any predetermined time is required before the release of the route is accomplished. The above require-

ments can be applied to trains running in one direction or both directions over a given piece of track.

Pros and Cons About Stick Locking. As stick locking and "Approach Locking" are arranged to provide the same protection it might be well for comparison to point out the advantages and disadvantages of stick locking. In stick locking the disadvantage lies in the difficulty of making signal tests, because whenever a signal is cleared the route is locked and can only be restored to normal conditions by the manipulation of the screw release. This is objectionable at a power plant where heavy traffic and perhaps the large number of signals will not permit the route to be tied up even for the least length of time, and particularly in places where the rules of the railroad require the towerman to test the movements of all levers when coming on duty. At a mechanical plant it will be annoying particularly in winter when it is necessary to move the signals frequently to keep them from freezing. At any plant it will interfere with the flexibility of operation for the reason that if the wrong route is lined up by mistake the locking of the route when no train has accepted the signal will cause a delay. This disadvantage is offset as approach indicators are a requirement in up-to-date stick locking when applied at busy interlockings so as to announce the approach of trains to the leverman and prevent delays which would occur if the route was lined up and signal cleared before a train was approaching the distant signal. The advantage of stick locking is the simplicity of the circuit, as the locking circuit in other styles consists of multiple circuits which necessitates the breaking of two paths instead of one before the locking of the route is effected. It also compels deliberation in action on the part of the leverman before clearing a signal and compels him to more closely attend to his duties because a signal cleared must also be accepted by a train to effect the release of the route; or the emergency release will have to be manipulated before conflicting routes can be cleared. This will prevent the possibility of a signal standing at clear any length of time. Briefly, stick locking, is considered by many engineers to promote discipline. Stick locking is very popular at places where economy is desired because only one track section or only one track instrument is necessary for each route.

Time Locks. The most primitive and simple way of applying stick locking at an interlocking is by the employment of a time lock. The idea of a time lock was first developed with the desire of protecting a derail which, by reason of being located close to a signal, could not be properly protected by a track circuit on account of track relays responding too slowly. It was also applied with the purpose of providing route locking at a nominal cost for slow speed train movements without the use of a track circuit or track instrument as a locking and release medium. It is also employed where the maintenance of electrical devices are objectionable. A time lock is a mechanical device designed to be used in lieu of an electric locking circuit. It will introduce a time element between the placing of a signal or other lever normal and prevent any change in the route governed by the signal upon whose lever it is placed until released by the lock. The time lock will permit the reversal of the lever but it will prevent its complete normal release until the expiration of a predetermined time interval. The time lock will accomplish three things: (1) If a route is not accepted by a train it will compel the operator to use deliberation before changing the route; (2) if a route is accepted by a train it will prevent the throwing of a derail or switch in the face of a train, and (3) it will prevent the immediate change of a route after a clear distant signal is accepted by the engineman. In the latter case it will be obvious that if a train requires 30 seconds to run between the distant and home signals the time lock adjusted to release on this time or longer after it is placed normal, will prevent the change of the accepted route until the lever is released. The time lock has the same characteristics as a half reverse lock, namely, the lever is free to be placed in the normal indicating position but cannot be placed full normal.

The time lock when applied to a slow speed signal lever for route locking protection only and not for the approach protection of high speed trains, must have the time interval necessary for its operation so adjusted that its length will provide the desired safety to train movements, but no longer than absolutely necessary so as to result in decreasing the capacity of the road. Should, for instance, the leverman make a mistake and line up the wrong route, in all probability the waiting train will be delayed during the time the locking is being released. In addition,

switching movements are likely to be hindered by time locking unless great care is used in its application. In many cases it is out of the question to so apply it as not to interfere with main line switching movements.

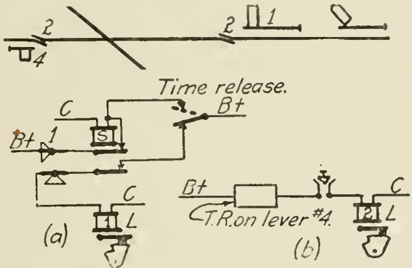


FIG. 117.

Time Releases. A time release may also act as a time lock by attaching it to a lever in the interlocking machine so that when it has once been actuated from its normal position by the complete or partial reversal of the lever it will not close an electric circuit until a predetermined interval of time has elapsed. The time release may also be placed on the wall in the interlocking tower. The locking is generally accomplished by a lever lock controlled by the time release. Referring to Fig. 117a, it will be observed that a time release is employed to pick up stick relay S, which becomes de-energized with the reversal of lever 1. In order to pick up the stick relay the time release must be reversed after lever 1 is put to the normal indication position. As soon as the normal contact on the time release is again made, the half reverse lock L on the signal lever 1 will be released. It is to be noted that with all applications of time releases the locking should be effected with the partial reversal of the signal lever. Time releases, as well as time locks, can of course be placed on crossing, route, F. P. L., derail and switch levers instead of signal levers, but it should not be effective except upon the manipulation of a signal or a route lever.

For slow speed movement an arrangement as shown in Fig. 117b is often employed. A time release on the dwarf signal lever will close a circuit after a time interval which will cause the energization of the reverse lock on derail lever 2. In the latter case the time release is adjusted to release on 10 seconds, although at small interlockings it is made longer.

Without the Employment of a Stick Relay. Fig. 118 shows an arrangement where stick locking is accomplished without the use of a stick relay. The reversal of the signal lever 1 will lock the route until the train has entered onto C track section. The release is accomplished outside the limits of the interlocking which will give full section, route and stick locking. Track sections A or B, however, can also be employed as release mediums or, for that matter all of them in multiple if desired so as to give the leverman more time in which to place the lever

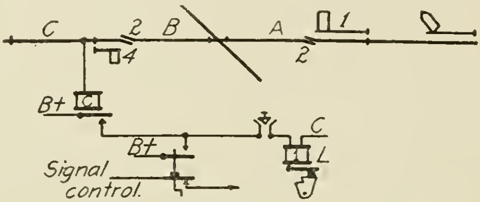


FIG. 118.

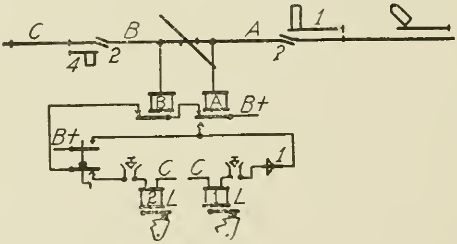


FIG. 119.

normal. The lock employed is a half reverse lock on the signal lever. Contrary to the majority of electric locking circuits where the lock might be applied to any lever desired, in the present circuit the lock cannot be placed on a switch or derail lever because these levers must be free to be manipulated whenever a signal is not cleared. Also, as previously stated, the stick locking shall only take effect upon the reversal of a signal lever or the clearing of a signal. The screw release is employed as discussed in former articles. To release the signal lever in the first track section of the route but still retain the section locking it will be necessary to employ an additional lever lock and place this on the derail lever. An arrangement of this kind is shown in Fig. 119. In this figure the reversal of screw release will release the stick locking, but the section locking release will not take place

until the release is placed normal again. It is to be noted that in most schemes of stick locking the lever must be placed normal or rather the release of the locking must be accepted while the train is moving in the releasing track section. This is an advantage where signals are not of a semi-automatic type as it prevents the leverman from neglecting to place the signal at danger after the passing of a train.

Compulsory Restoral of Signal Lever. With any class of electric locking the circuits may be so arranged that it will be necessary for the leverman to restore his signal levers to the normal position while a train is passing between any two predetermined points in order to release the locking; or it may be so arranged that the locking will release automatically, whether the operator restores the signal levers or not. Each method has its particular advantages. If it is necessary to restore the signal levers to normal at a certain time in order to release the locking, the leverman will have to be more attentive to the work than with the other arrangement, in order not to delay following trains or trains on conflicting routes. When automatic control of the signals is not used this is the only practicable method of compelling the leverman to restore the signals to the stop position behind each train. On the other hand, if it is not necessary to restore the signal levers to the normal position at a certain time in order to release the locking, the leverman will be more free to attend to other duties which are likely to make demands upon him, such as taking train orders, etc.

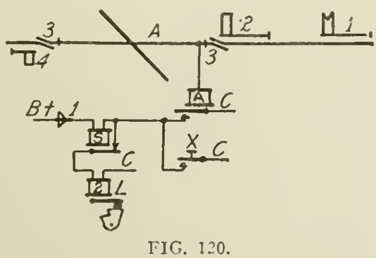


FIG. 120.

Stick Relay and Locks in Series. An arrangement which was used in the early days of signaling and which was mentioned in Chapter VI. is shown in Fig. 120. The reversal of lever 1 will drop the stick relay S and also lock L on signal lever. When

the train enters onto track section A the stick relay is picked up through the back point on the track relay, provided lever 1 is placed normal. The lock, however, will not pick up until the track relay is energized on account of the low resistance shunt provided by this point. When A is energized the lock picks up in series with the stick relay. The advantage of this style of locking circuit is that only one stick relay is required for a number of signals; a number of lever locks can be placed in series; and, by controlling the stick relay through back points of all the track relays where the locking is desired to be effective, section locking will be provided. The disadvantage is the difficulty in providing the proper relative resistance in the relays and locks when many are placed in series, with the battery in extreme good and poor condition. A hand key X is here used as an emergency release medium and will have the same effect as the dropping of the track relay.

Normally Energized Stick Relay. Stick locking can be accomplished by the means of a normally energized stick relay, an example of which is presented in Fig. 121. The clearing of

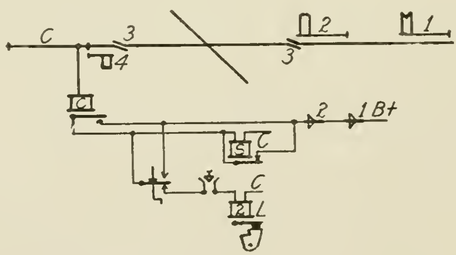


FIG. 121.

signals 2 and 1 will drop the stick relay 5 which again will de-energize the signal lever lock L, which is here controlled in multiple with relay S. The stick relay will pick up when train enters onto section C and the signal placed normal, when lock L will pick up through lever contacts, stick relay, screw release and floor push. The stick relay may be controlled through the home or the distant lever contact only. The lock and stick relay may also be controlled as in Fig. 122 through contacts on all the signals in series. The lock is here controlled through a front point of the track relay so that the route will be released only with the pick-

ing up of the stick relay and the track relay, hence affording section locking. By substituting the lever contacts with contacts controlled by the signal arms indication locking will be provided.

When a normally open track circuit is employed the stick relay will pick up on the front point of the relay and the lock will be controlled through a back point. In Fig. 123 an arrange-

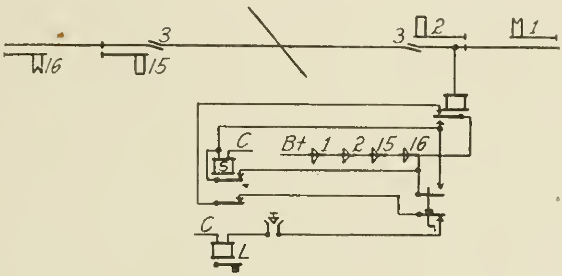


FIG. 122.

ment for use at an electric road crossing is shown. It will be noted that the clearing of signal 1 will drop the stick relay S and a train moving in the direction of the arrow, upon entering the insulated third rail or trolley wire, section X, will pick up releasing relay A. For further details of an arrangement of this kind the reader is referred to chapter VI.

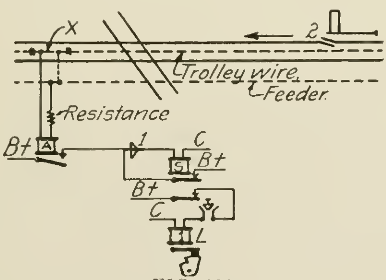


FIG. 123.

With Semi-Automatic Signals. When semi-automatic power signals are employed it is customary to provide indication locking in addition to stick locking and the stick relay is controlled through circuit controllers on the home and distant signals, as shown in Fig. 124. By so doing, the stick relay will not drop with the reversal of the signal lever except when the

signal is cleared. Another advantage is present—the lever does not have to be placed normal while the train is occupying the releasing track section. Should the compulsory restoral of the lever be desired while the release by the train is effected, the lever contacts can be inserted as shown in dotted lines; wire X coming out.

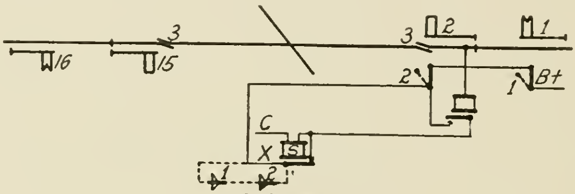


FIG. 124.

Where mechanically slotted signals are employed it is recommended that two contacts in series be used for each signal lever when the restoral of the lever is desired. One contact will be controlled by the tail lever and another by the lever latch. The former contact is used to insure that the lever is in the normal latching position and the mechanical operating parts of the signal normal; the latter contact to insure that the lever latch is up and the electric control of the signal broken. There are roads that find it advisable to employ two contacts wherever a signal is controlled and operated from a mechanical interlocking machine.

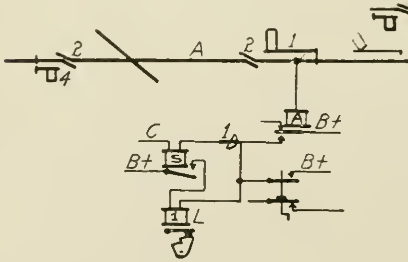


FIG. 125.

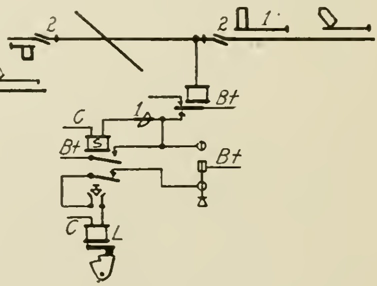


FIG. 126.

Normally De-Energized Stick Relay. The use of a normally de-energized stick relay will save current consumption and the circuit can be arranged as shown in Fig. 125. With the reversal of the lever and the train in track section A the stick

relay S will pick up through the back point of track relay. The lever lock L, being controlled in series with the stick relay, will pick up as soon as the track relay drops, which is contrary to the action previously described in connection with stick relay and locks in series. The placing of the lever fully normal will again drop the stick relay.

A circuit where the lock is separated from the stick relay circuit is shown in Fig. 126. The lock can be controlled through front point of track relay for section locking purposes. To show the different methods of release a knife switch is here shown as an emergency release medium, and to prevent hasty action should be located in the lower story of the tower.

Attention is called to the fact that where a normally de-energized stick relay is employed compulsory restoral of the signal lever normal is not necessary.

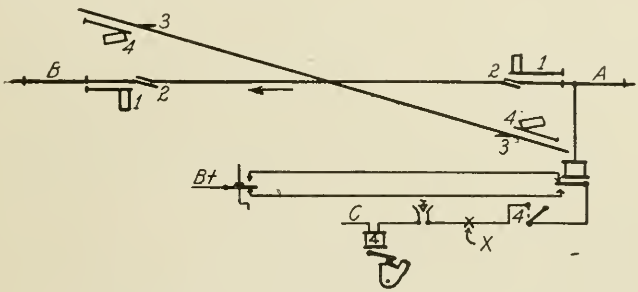


FIG. 127.

Crossing Protection. At crossings between two railroads where light traffic does not warrant the employment of a signalman in the interlocking tower stick locking can be provided, as shown in Fig. 127. The signals 4 are normally set clear, as they protect road with the heaviest traffic. For the sake of simplification, assume the circuit as being designed to protect a train moving in the direction of the arrow. A train entering track section A will release the lock as soon as the trainman has put signals 4 at danger. If for any reason the relay is not de-energized the slow release reversed will shunt out the track relay back point. Lock wire at X can be broken through track relays located in advance of signals 4, thereby insuring that no train is approaching the interlocking or has accepted the clear signal in the conflicting road. This wire should also break through the

opposing signals 4 in series and in multiple through a back point of relay for track section B. An arrangement for a single track crossing a two or more track railroad is shown in Fig. 128. This is designed to protect the train by electric locking also while it is occupying the dead track section at the crossing without the use of a trap circuit. Only one stick relay S is necessary, and the clearing of either signal will cause its de-energization. In order that the release of the stick locking, with a train moving in the direction of the arrow, will not take place until

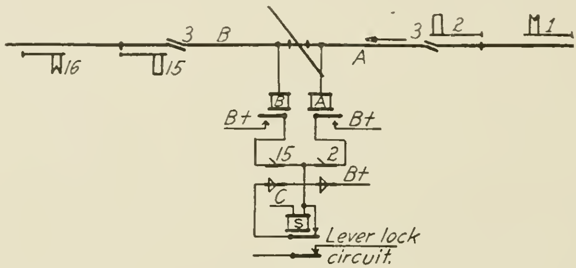


FIG. 128.

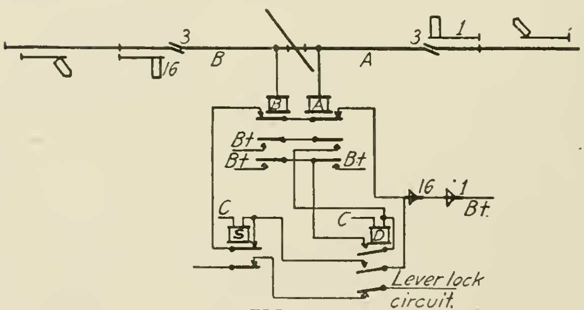


FIG. 129.

the train has entered onto section B, the release wire is broken through a full normal contact on lever 15. As the lever locks 2 and 15 are controlled through the stick relay it is evident that lever 2 cannot be placed full normal and consequently the stick relay with signal 2 cleared cannot pick up in section A. It should also be apparent that in this scheme the locks must be applied to the signal levers. By controlling the locks through a front point of the track relays the train must have passed out of the section before the route is released. In Fig. 129 two stick relays are employed to insure that the train passes over

the crossing before the release of the stick locking is accomplished. Stick relay D will pick up when a train is on the crossing by the pick-up circuit breaking through both relay back points in series and the relay will stay picked up as long as a train is occupying either track section A or B. Stick locking relay S will pick up through a front point of relay D and normal contact on signal levers. It cannot stick up until the track circuits are unoccupied, when relay D, of course, is dropped. The lever lock can be controlled through front point of relay S and back point of relay D, which will give section locking in addition to stick locking.

At Power Interlockings: In stick locking the arrangement at power interlockings can be made as covered in chapter VI. Lever locks can be employed in a similar manner, as at mechanical plants, and the indication wire can also be controlled as shown in Fig. 130. The indication for the signal is here

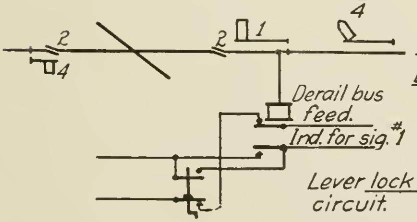


FIG. 130.

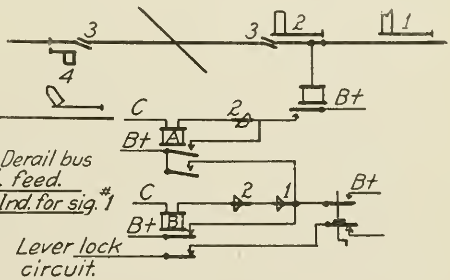


FIG. 131.

broken through a back point of the track relay, which will prevent the unlocking of the signal lever until the train has entered the track circuit. The slow release will shunt out the track relay contact, but the switch bus bar feed or switch lever lock circuit will be open until release is placed normal. In place of breaking the indication wire through a back point of the track relay the wire can be controlled through front points of a stick relay. The signal indication wire is also often selected on switch lever contacts so as to break through track relays with different line-up of switches. In a complex track layout the selection and breaking of the indication wire through track relays often introduces complications in an otherwise simple circuit, and it will be found to be of advantage to substitute lever locks.

In Manual Block Territory. At interlockings located in a single track manual blocking system and where the conductor as well as the engineman is held responsible for the position of the signal it is a general rule that in case the signal is placed normal before the caboose has passed it, the conductor's duty is to get the train stopped and find out the cause. In case a normally energized stick relay scheme is employed and the pick-up section is short it has happened that the towerman, to be sure to release the route, has put the signal back before the caboose has cleared the signal. To permit the release of the route, even if the signal is left clear with the train out of the release section, two stick relays must be employed, as shown in Fig. 131. Stick relay A will pick up on back point of track relay and stick relay B will pick up on front point of relay A when lever is put normal. The lever lock circuit is broken through relay B. Relay A will drop when lever is placed full normal.

Stick and Indication Locking. In all schemes described in this chapter it is, of course, possible to provide indication locking by breaking the stick relay or the lever lock through normally closed circuit controllers on the signals for which an indication is desired. Where semi-automatic signals are employed the release of the route will of course be accomplished automatically when the train enters the track section without the compulsory restoral of the signal lever. Where mechanically slotted signals are used it is to be understood that no indication is required because the mechanical operation of the signal is so arranged that if the signal should stick clear electrically the restoral of the lever will mechanically pull it to danger position. It should be obvious that the stick relay should only break through the signals by which the locking is desired, also that when breaking a stick relay control through a circuit-breaker on the signal blade the controller should break the relay circuit only when the blade is in the position in which route locking is desired. Where a three-position distant signal is employed the stick relay should only respond when the signal goes above the 45° position and the contact should be arranged to make between the 0° and 45° position.

By employing an indicator as a stick relay a visual indication

of the signal arm going to danger will be provided for the leverman, and also, if anything goes wrong with the locking circuit it will tell the leverman that the position of the signal has nothing to do with the trouble.

STICK AND SECTION LOCKING. In order to provide section locking in combination with stick locking for a train movement under a clear signal only the stick relay should pick up in the last section in the route or the first section beyond the interlocking. Also the lock relay or lever lock should be broken through the track relay points (front points) in the route, and thereby provide full section locking protection if the switches and derails have lever locks.

EMERGENCY RELEASES. Whenever a stick relay is released by the reversal of a slow release the lock which is released by the stick relay should be broken through a normal contact on the release. If the release does not contain enough contacts for this purpose a relay can be controlled by the normal contact on the release and the lever locks through a front point of this relay. In stick locking the slow release will of course always shunt out the releasing medium as the back point of the track relay, a point on a track instrument, or time release.

THE CONTROL OF THE STICK RELAY. Stick locking is most frequently employed for high speed routes only and for that reason the selection of its control wire is often required. An

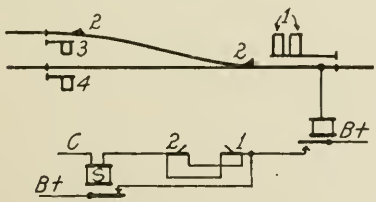


FIG.132a.

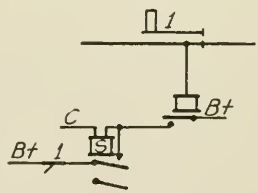


FIG. 132b.

example of a selective dropping arrangement is shown in Fig. 132a. The stick relay S will drop when signal 1 is cleared for a movement over switch 2 normal while 2 reversed will keep the stick relay energized.

Where the compulsory placing of the signal lever is desired before the route can be released the stick relay stick-up or pick-up wire should break through contacts on the signal levers closed only with the signal assuming the stop position. With a normally de-energized stick relay scheme the circuits previously shown will pick up stick relay without the placing of the lever normal. In Fig. 132b an example is shown where the lever must be placed normal before the stick relay is picked up. Where the stick relay is to be controlled through circuit controller on the home and distant signals for two routes a selection of the control wire is necessary or else two stick relays must be employed. Where a stick relay control is selected because one stick relay is employed for two converging routes, the selecting contacts must be arranged to make before break. Thus, in Fig. 133 it

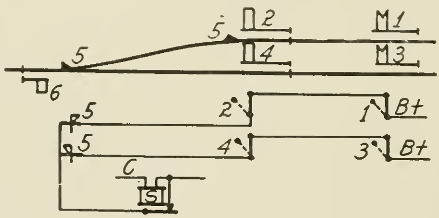


FIG. 133.

will be observed that the controllers on switch or switch lever 5 must not break while being manipulated. In selecting a pick-up wire the mentioned precaution does not apply. One stick relay cannot be employed for two routes which can be cleared simultaneously. In Fig. 134 the stick relay, if complete section lock-

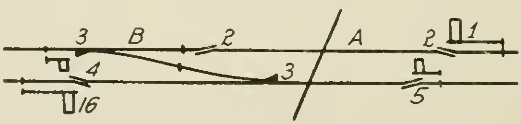


FIG. 134.

ing is provided, can pick up in section A because lever 2 reversed locks 3 normal, and while the stick locking is released with a train in A, lever 2 is locked by the train occupying this section and lever 3 is locked by lever 2. With the train in section B, lever 3 is locked by the section locking. Cross-over 3, being a trailing point cross-over, need not break through stick relay for signals 1 or 16, because it is locked by derails 2 and 4

reversed, and these derails break through the stick relays and slow releases. Hence, where section locking is employed the pick-up of the stick relay will not release the route until the train has passed out of the track sections controlling the lever locks. In Fig. 135 the pick-up wire for stick relay for signals 1

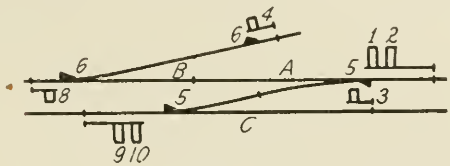


FIG. 135.

and 2 need not be selected on lever 5, but stick relay can pick up on track relay A. The lock for lever 1, however, will break through track relays A and B (signal 1 governing over 5 normal), and the lock for lever 2 (signal 2 governing over 5 reversed) through relays A and C in addition to breaking through the stick relay. The stick relay pick-up wire may also be broken through front points of the track relays within the interlocking in series with the back point of the track relay outside the limits of the interlocking, as shown in Fig. 136. This

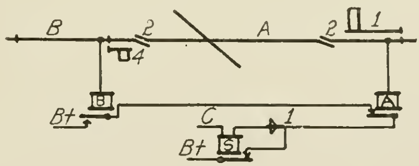


FIG. 136.

will give positive assurance that a stick relay will stay de-energized while a train is moving through the interlocking, and that the train is completely out of the route before the stick relay is released. The stick-up wires should not be broken through a front point of the track relays except in special cases, because a train may cause the dropping of stick relays which should remain energized. A minimum number of contacts in the release circuit is an important factor in the design of stick locking circuits, and so far as is practicable these circuits should be made continuous without its contacts being made mechanically. The additional contacts used in some schemes introduce additional chances for failures.

Selection of Stick Relay or Lever Locks. If a simple track layout as in Fig. 137a is to be provided with stick, section

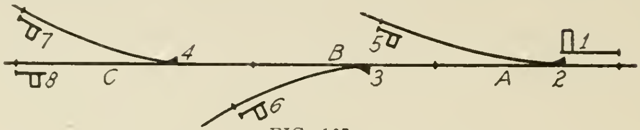


FIG. 137a

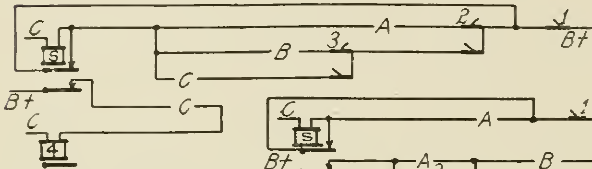


FIG. 137b.

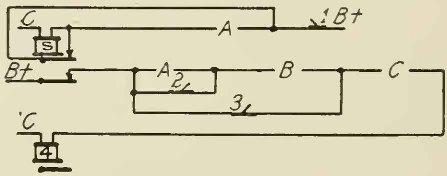


FIG. 137c.

and route locking it can be arranged by having the stick relay pick up wire selected so that with the clearing of signal 1 and a straight line-up of switches the stick relay will pick up on the last track section in the route. That is, with levers 2, 3 and 4 normal the stick relay will pick up on back point of track relay C. If lever 3 is reversed it will pick up on back point of relay B, etc. In this case it will only be necessary to control lever lock 4 through the stick relay and track relay C, as shown in Fig. 137b. If the stick relay is arranged to pick up on track relay A at all times it will be necessary to control lever lock 4 through all the track relays in the route in series and shunt out of certain track relays with different line-up of switches, as shown in Fig. 137c. Should route and stick locking be desired the lock shown in Figs. 137b and c might be placed on the signal lever and either one of the circuits shown employed. It will be noted that the two last described circuits will give the same protection, but at complex situations one might be employed to better advantage than the other.

Example of Elaborate Arrangements. In Fig. 138, which shows an elaborate stick locking arrangement, indication locking and section locking protection are also provided for. With a train accepting the route and having entered track section A,

the stick relay S will pick up, provided the lever is placed in the normal latching position. The signal lever lock will energize when the train is out of section A, and, by the placing of the lever full normal, the stick relay will again drop. Should the trainman neglect to throw his lever normal until the train has passed out of the track circuit or if he wishes to change the route before the train arrives, it becomes necessary to reverse the screw release F. This will pick up stick relay, but in order

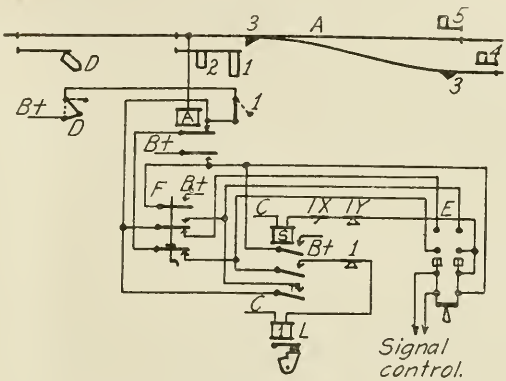


FIG. 138.

to release the lever lock, the release must again be placed normal. In case of a failure of the local battery or the track circuit the emergency switch E, which is enclosed in a locked case with a glass cover and generally placed downstairs in the tower, is introduced to shunt out the track relay and connect the lever lock and stick relay with the outside battery. The throwing of switch E and screw release F will energize stick relay, which will stick up with screw release restored normal from battery at distant signal. The lock will be energized through the screw release normal, emergency switch reversed and front point of stick relay. In order to again clear the signal the emergency switch must be placed normal, as the signal control is broken through a normal contact. It will be noted that the stick relay will energize through two signal lever contacts in series; one contact operated by a controller attached to the tail lever X and another operated by a controller connected to the lever latch Y. The lever lock is controlled through a contact on the lever latch controller closed, while the latch is in the raised position.

Application of Lever Locks. In view of the fact that stick locking differs from route locking by its effecting the locking of a route by the clearing of the signal and the protection which it is designed to give to an approaching train, it is evident that the disadvantages mentioned in route locking as to the placing of the lever lock on the signal lever are not present in stick locking. In stick locking a route shall be protected with the clearing of a signal, and consequently the condition of the locking of a route with a train movement under a hand signal does not exist. Hence a half reverse lock on signal levers is most frequently used in stick locking and additional protection section and route locking provided by locks on F. P. L., switch and derail levers. Crossing levers and route levers can be employed to advantage also in stick locking by controlling their lever locks through stick relays which again are controlled by the signals. At plants where stick locking is employed for high speed movements it is customary to provide section locking or route locking, or route locking only for slow speed movements, to avoid the inconvenience resulting from the lining up of wrong routes, and also because no advance signal indication is given for such train movements. The precaution given in section locking when controlling lock relays and locks also obtains in stick locking and further discussion should not be necessary.

VIII

APPROACH LOCKING

Definition. Approach locking is given the following definition by the Railway Signal Association: "Electric locking effective while a train is approaching a signal that has been set for it to proceed, and adapted to prevent manipulation of levers or devices that would endanger that train." Approach locking, like stick locking, is generally employed at places where trains pass at high speed, and is intended for the protection of an approaching train. While stick locking takes effect upon the clearing of the signal, true approach locking takes effect only when a train is approaching and a signal is clear. Approach locking is also sometimes termed "advance locking" and applied to lock routes other than high speed routes by effecting the locking of the route before the train has actually entered it.

Requirements. Approach locking should be made effective with a train passing a predetermined point while approaching an interlocking with the governing signal in a certain position. (The signal should be at clear or display a caution or proceed indication.)

The locking should be effective at such distance from the governing signal where it is visible to the engineman.

Approach locking can be made effective with a train movement in one or both directions.

From this it will be evident that approach locking should take place at such a distance from the signal or signals (when a distant signal is employed) governing the route that the route cannot be changed after it has been accepted by the engineman, and if abnormal conditions require that the signal be taken away after it has once been accepted, the interposed time interval should be long enough to allow the train to come to a full stop before the accepted route is free to be changed.

Advantages and Disadvantages. The disadvantages peculiar to stick locking where the clearing of a signal will effect the locking of a route are not present in approach locking. Its application will in many respects complicate or necessitate a more expensive installation as compared with stick locking; in fact,

many roads consider its employment prohibitive on that account and especially at small interlockings, where line circuits are undesirable. Furthermore, sole dependence is placed upon the action of the "approach lock wire" or the action of the approach indicator for the actuation of the locking. It might be said about any scheme of electric locking that whatever additional contacts are employed will introduce proportionate chances for failures, although proper precautions may be taken in the design to eliminate failures which might prove a source of danger. Among the advantages is the facility with which a signal may be tested without inconvenience, and the fact that it is not necessary for the operator to observe the train in order to place the signal lever normal while it is in the releasing section. The latter advantage of course might be considered a disadvantage by some engineers. Consequently, in approach locking, if a mistake is made in setting up a route, and it is discovered in time the train will not be delayed, as an immediate change of line-up is possible. In most styles of approach locking means must be employed which will compel the leverman to place the signal lever normal after a signal is passed by a train where "stick" signal control arrangement is desirable. This is not always considered necessary where stick locking is employed.

Approach Indicator. An approach indicator is considered by many roads a necessary adjunct in connection with approach locking. The control of this indicator differs according to the requirements at the point where the approach locking is applied. Some roads stipulate the announcement of trains to take place when the train is not less than one mile in the rear of the distant signal. Referring to Fig. 139a the indicator might be controlled

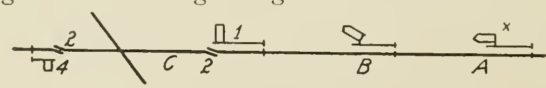


FIG. 139a.

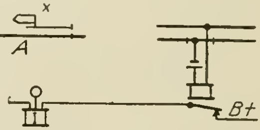


FIG. 139b.

through track section A or B only; through A and B in series or through all intervening sections from signal X to 1, depending upon the scheme of approach locking employed. Where no auto-

matic block signals are employed it may break through a short track section or track instrument located ahead of the home or, where such are employed, ahead of the distant signal. An example of the application of a short annunciator track section is shown in Fig. 139b. One rail only is insulated, and the distance between joints is one or two rail lengths. A train bridging the rails at this point will de-energize approach indicator I. The approach indicator when applied in connection with approach locking should always be normally energized, as it is safer to place dependence upon the de-energization of an apparatus than upon its energization. In the subject under discussion it is of utmost importance that the approach indicator respond with a train in the advance section, and it is safer to have the indicator normally energized and depend upon its de-energization than to have it normally de-energized and depend on its energization for the actuation of the approach locking. Where automatic block signals are employed the approach indicator may be controlled as in Fig. 139c. Here a train passing signal A will place

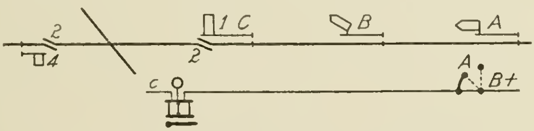


FIG. 139c.

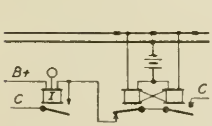


FIG. 140a.

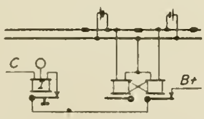


FIG. 140b.

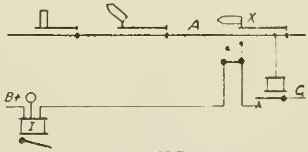


FIG. 141.

the signal at danger and break the control for indicator I, which will drop. A train passing signal B will again pick up I, because the contact on signal arm A makes at 45°. This contact, however, may be arranged to make at 90° only, and indicator I will remain de-energized until the train has passed signal C.

On single track roads, or on roads where traffic in both directions over one track is the rule rather than the exception, it is desirable that the approach indicator be actuated only when trains are approaching the interlocking plant. Where no automatic signals are employed interlocking relays and short track circuit sections, as in Fig. 140, can be used to advantage. The

approach indicator can be made a stick indicator, and the circuit so arranged that its coil can be restored to its normal position by the leverman. Approach indicators of the drop annunciator type are often employed with circuit arrangements as in Fig. 140. Where automatic signals are in service the circuit can be arranged as in Fig. 141, in which the indicator picks up only when a train enters track section A with signal X in the 90 deg. position. It is evident that for opposing train movements the signal will assume the 45 deg. position before the track relay will become de-energized.

Audible Annunciator. In conjunction with the indicator an annunciator in the form of a bell or buzzer is generally employed so as to afford an audible as well as visual indication of the approach of a train. Since the expeditious clearing of a route and signal is of importance where approach locking is employed, various circuit schemes have been developed to insure that a train is properly announced when approaching the interlocking. It is also of importance that proper means be adopted to silence the buzzer or bell after it is observed by the operator so as not that it will not be a nuisance. Fig. 142a shows a buzzer ringing

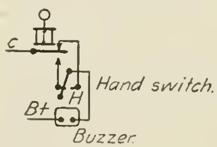


FIG. 142a.

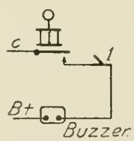


FIG. 142b.

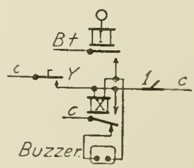


FIG. 142c.

through a hand switch and the back point of the indicator. The operator can in this scheme reverse the hand switch, after the indicator has dropped, and thereby stop the buzzer. As soon as the indicator picks up again it is necessary that the hand switch be placed normal, as the buzzer will sound through the front point of the indicator and the hand switch reversed. In scheme Fig. 142b the buzzer will sound through the back point of the indicator and lever contact when lever 1 is normal. With lever 1 reversed for the clearing of the signal the silencing of the buzzer will be effected. A more elaborate scheme is shown in Fig. 142c. The buzzer will sound through the back point of the indicator and back point of stick relay X. The depression

of hand key Y will pick up the stick relay, which will stay picked up through its own point and silence the buzzer. Should signal lever 1 be reversed before the indicator is dropped the stick relay will pick up when the indicator drops, and stay picked up. The placing of lever 1 normal will again drop the stick relay to its normal position.

SIMPLE STYLE OF APPROACH LOCKING. Approach locking can be arranged as shown in Fig. 143. The approach indicator should

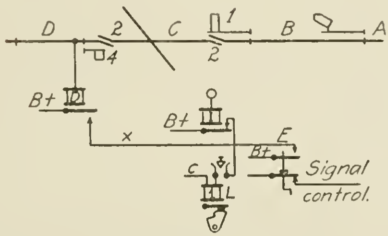


FIG. 143.

be controlled in series through all track sections in advance of the home signal 1 so as to retain the electric locking until the train passes the home signal. Thus, in a circuit of this style it is important that the indicator remain de-energized as long as the approach locking is desired to be effective. Because of the fact that approach locking shall only provide protection to a train approaching an interlocking it is evident that its release can occur after the train has passed the home signal. Hence it is merely necessary to control the half reverse lock L on the signal lever through the approach indicator I. Before the train, however, has entirely cleared track section C another train may have entered section A or B, thereby keeping the indicator I de-energized, which will prevent the signal lever from being placed normal and consequently keep the route locked up. This is, of course, undesirable because a different lineup of switches might be necessary for the second train. For this reason a shunt wire X is employed to shunt out the indicator in case one train follows another. This wire can connect to a back point of track relay for section C or section D, or both of them in multiple, if it is a busy terminal. Screw release E is employed as previously described.

With a Normally De-energized Stick Relay. In Fig. 144 the reversal of the signal lever and the dropping of the approach indicator I will pick up stick relay S, which will remain energized until the signal lever is placed full normal again. The lever lock is not released until the train has entered onto section C, when it is energized through the back point of track relay C. The

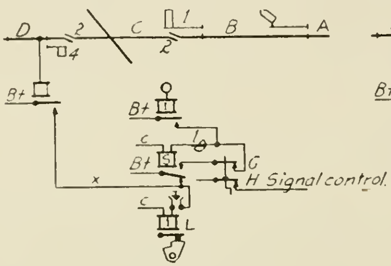


FIG. 144.

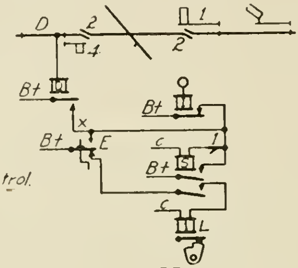


FIG. 145.

release of the route can also be accomplished by the reversal of the screw release, which will drop the stick relay S. With a release arrangement of this style the contact G should not break until the screw release is fully reversed and H contact should break with the starting of the reversal of the release. In the circuit Fig. 4 it is only necessary that the indicator I break through one track section, because the picking up of the stick relay will keep the route locking effective.

Another scheme employing a normally de-energized stick relay is shown in Fig. 145. Here the clearing of signal 1 and the dropping of indicator I will effect the approach locking. The lever 1 placed in the normal latching position, and no train in the advance track sections, will pick up relay S and permit the lever to be placed full normal by the release of lever lock 1. The stick feature of relay S is also utilized in the emergency release scheme. The reversal of screw release E will pick up relay S which will stick up through its own point. The placing of the screw release normal will release the lock. The placing of the lever full normal will again drop the stick relay. In the latter scheme it is obvious that the indicator must break through all advance track sections in series.

Normally Energized Stick Relay. A scheme employing a normally energized stick relay will necessarily be on the order

of a stick locking scheme, with the exception that the stick circuit will break through a contact on the approach indicator in multiple with the signal lever contact, as shown in Fig. 146. The stick relay S will only drop with the signal lever 2 reversed and the indicator I dropped. It will pick up through a back point of any track relay within the limits of the interlocking or

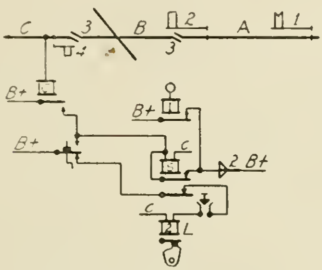


FIG. 146.

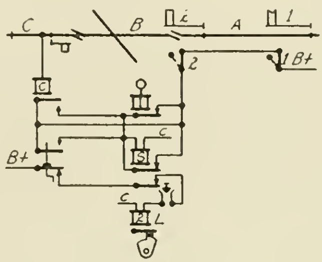


FIG. 147.

through all in multiple. It is to be noted that in this scheme the necessity of placing the signal lever normal while a train is in the pickup section and another approaching is apparent. The indicator needs only break through advance track section A.

Where combined approach and indication locking is employed in conjunction with a stick relay the circuit must be arranged differently, because the stick relay control will be carried out to the governing signals instead of through the lever contacts. Hence, in Fig. 147 stick relay S will drop when clearing the signals, but placing the signal normal again will pick up the stick relay, provided no train is approaching. If indicator I is de-energized the stick relay will not pick up until the track section C is occupied or the screw release is reversed. In this scheme it is necessary that the approach indicator be controlled through all the advance track sections in series. It will be observed that indication locking is provided, as the stick relay will not pick up unless the signals are fully normal.

Single-Track Application. Approach locking applied to a single track layout may be arranged by duplicating the previous schemes, one for each direction, and also as illustrated in Fig. 148. Approach indicator 16 is controlled through track section E and indicator 1 through section A. The stick relay control is so

selected that if a train should cause the dropping of indicator 1 by entering section A with signal 16 at clear the stick relay will not drop. With signal 1 clear and indicator 1 dropped the stick relay will be de-energized and not pick up until the train has entered the interlocking limits. In an approach locking scheme employing a stick relay no provisions for a second approaching

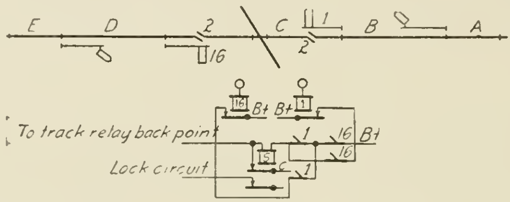


FIG. 148.

train are necessary. A single track approach locking circuit can also be arranged as described in "Route Locking" by the employment of interlocking relays having special points equipped with bone insulation.

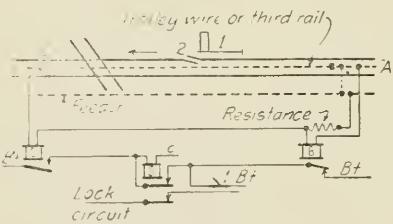


FIG. 149.

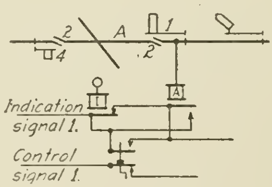


FIG. 150.

At Electric Railway Crossings. At electric railway crossings a circuit can be arranged as in Fig. 149, without the employment of a track circuit. A car running in the direction of the arrow will, upon entering the insulated trolley wire section A, pick up approach relay B and if signal 1 is cleared will cause the dropping of stick relay S through which the lever lock is controlled. The car, after reaching insulated section C, will pick up releasing relay D and cause the energization of stick relay S, which will remain picked up irrespective of the position of the signal lever. It will be noted that the stick relay will pick up even if another car is following the first, provided the signal lever is placed normal, so that no extra release wire is necessary for following car movements.

At Power Interlockings. Approach locking at power interlocking plants can, as in Route and Stick Locking, be applied by an interruption of the indication wire. It can also be applied as described in the foregoing parts of the present article. If indication is interrupted the scheme will be as illustrated in Fig. 150: the indication wire is broken through the approach indicator for electric locking purposes; in multiple through the track relay back point for following train release purposes, and a reverse contact on the screw release for emergency release purposes. The approach indicator must break through all the track sections in advance of the home signal.

A more complicated arrangement is presented in Fig. 151 to

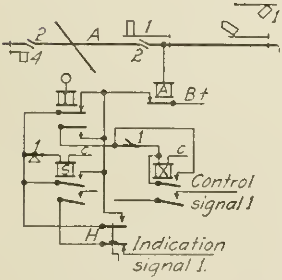


FIG. 151.

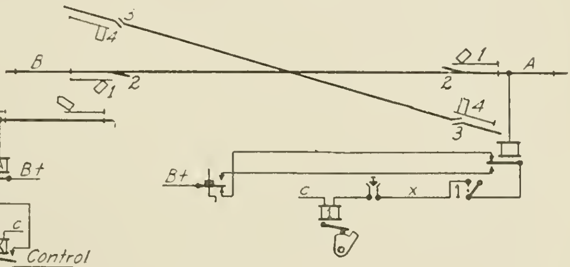


FIG. 152.

illustrate variances in approach locking arrangements. In this circuit the operator is restricted so as not to clear signal 1 unless a train is approaching. This is accomplished by a stick relay X which is used as a signal control relay and which will pick up only, with no train in track section A, a train in the approach track sections and the signal lever full normal. The reversal of the signal lever will clear the signal as the stick relay X will stay picked up through its own point which shunts out normal contact on lever 1. Under normal conditions the approach locking will be released by the placing of signal lever 1 in the normal indication position, which will pick up stick relay S and complete the indication circuit for signal 1 through the front point of this relay. Under abnormal conditions the release of the locking with the approach indicator de-energized can be accomplished by the reversal of the screw release H, which will pick up stick

relay S by shunting out the indicator I. Relay S will stick up but the release must be placed normal before the indication can be procured. Stick relay S will drop with the placing of lever 1 full normal. Approach indicator I must break through all advance track sections. It should be observed that by breaking the stick relay S pick-up wire through a front point on track relay A, section locking is also provided in this circuit.

Crossing Protection. Approach locking can be applied to single track crossings where on account of light traffic it is not necessary to have the constant attention of a leverman. The signals on the road with the heaviest traffic are set normally at clear as shown in Fig. 152, and are in the present case signals 1. The protection is, for the sake of clearness and briefness, designed to give protection for a train movement in one direction only, that is from A to B. A trainman on a train approaching signal 4, must enter the interlocking tower and place signal 1 normal. In order to release lever 1 the signal must have assumed stop position, no train can have entered approach section A and the screw release must be normal. Should a train be standing in advance of signal 1 the reversal of screw release and with relay A de-energized the release of lever 1 will be effected. The screw release should, if an electro-mechanical, lock lever 4 normal to insure its restoral normal. If an electric screw release, the control for signal 4 should break through one of its normal contacts. Wire X should also break through a normal contact on the opposing signal 1 and a contact on track relay B.

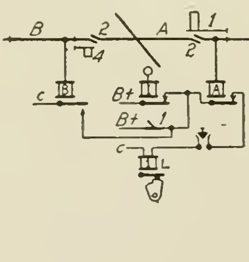


FIG. 153.

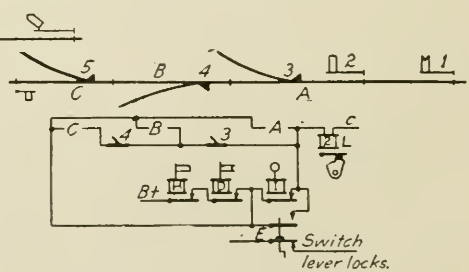


FIG. 154.

Combined Approach and Section Locking. Approach and section locking protection can be provided by controlling the lever lock in multiple through a point of the indicator and a

lever contact, and in series through the track relays within the interlocking limits. As in Fig. 153 the lock can be placed on the signal lever and the pick-up of the lock in case of a second train must occur outside the track section controlling the lock. Where a stick relay is employed and the lock placed on the signal lever, section locking can be provided by having the stick relay pick up outside of the interlocking limits. The section locking obviously is only effective with a signal clear. Locks on switch and derail levers controlled through track sections will of course provide section locking but should be applied independently of the approach locking and as described in "Section Locking."

Combined Approach and Indication Locking. By controlling the lever lock through a circuit controller on the signal, indication locking in addition to approach locking will be provided. By controlling the stick relay as described in connection with Fig. 147 the same will ensue. In Fig. 154 an arrangement which is very popular at large plants is shown. Here an indicator is employed for each signal. H is controlled and indicates the position of home signal 2 and D the same for signal 1. Thus by breaking the control for lever lock 2 through these indicators in addition to the approach indicator I an indication will be provided for the signals. The approach locking will take effect when indicator I is de-energized and this indicator must break through all the sections ahead of the home signal in series. Screw release E will shunt out the approach indicator should a change of the route be necessary with a train in the approach sections. As switch lever locks providing section locking are generally employed in an elaborate scheme of this kind, these will break through the normal contact on the release. In the case of a second train approaching the plant the release of the lever lock is selected on the various switch levers. The selection is necessary so that a train moving in track section C, while a route over 3 reversed is lined up, will not release the route with a train approaching the plant.

In Fig. 155, the clearing of signal 1 will drop the stick relay S regardless of the approach of a train, but by restoring the signal lever to the normal latching position the stick relay S will again pick up, providing home and distant signal assumes the normal position and the plant is restored to normal operating con-

ditions. Instead of taking battery for the stick-up circuit through lever contacts, the circuit could be arranged as shown by dotted line X, thereby eliminating the contact on levers 1-2. These contacts, however, are employed in many installations so as to localize the holding circuit and not use the automatic signal battery for the purpose of energizing the stick relay. Approach indicator must be controlled through all advance sections.

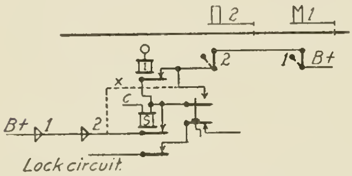


FIG. 155.

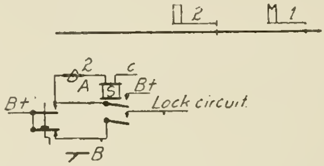


FIG. 156.

Emergency Release Arrangements. In addition to a screw release a stick relay may be employed as a release medium as shown in Fig. 156. While lever 1 is reversed and indicator 1 de-energized the reversal of the screw release will pick up the stick relay S, and by placing the screw release normal the lock will be released. The contact on the lever for signal 1 can be arranged to make as at A or as at B. It must be assured in either case that the contact breaks with the lever placed in the full normal position. Attention is called to the fact that in approach locking the release circuit should effect the shunting out of the approach locking mediums only. For example, at places

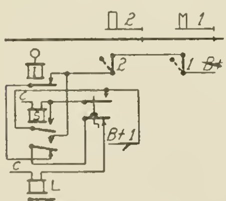


FIG. 157.

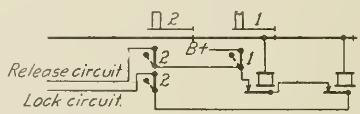


FIG. 158.

where indication locking is combined with approach locking and where an approach indicator is employed, the release circuit should shunt out the indicator but not the signal circuit controllers as shown in Fig. 157. Where no approach indicator is used the arrangement Fig. 158 is frequently employed. Here the lock circuit breaks through the signals and approach track

sections while the release circuit breaks through the signals only. Approach indicators are often controlled as in Fig. 159, thereby acting as a signal repeater as well as an indicator. In this case the release circuit will either break through a signal lever contact or a separate wire out to the signal. Another method of

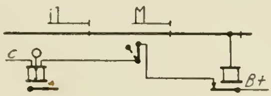


FIG. 159.

FIG. 160.

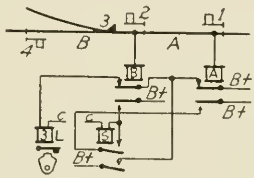


FIG. 161.

controlling an approach indicator is shown in Fig. 160. Here the indicator will drop when the signal is at danger only and a train approaching. The indicator will also here act as a signal repeater by showing if a signal has responded to a lever movement with a train on the approach circuit.

ADVANCE LOCKING. Advance locking is very similar to approach locking in that it locks up a route before the route is entered, but it is employed for slow and medium speed train movements only and really is a modification of route locking or rather sectional route locking, the difference being that it is effective before the route is entered. In Fig. 161 it is desirable to lock up the switches and derails in track section B, when the train enters section A. This is accomplished by controlling lock 3 in series through track relays A and B. A train moving in the opposite direction from B to A, should not keep lock 3 de-energized after it has passed out of section B and onto Section A, as this would tie up that part of the plant as long as a train remained in section A. With the employment of stick relay S a train entering section B first, will pick up this relay through the back point of track relay B and it will remain energized as long as sections B and A are occupied. The front point of stick relay will shunt out contact on track relay A thereby releasing the lock with a movement from B onto A. It is to be noted that the lock is always controlled through track relay B so that section locking is provided at all times. If switches in section A are to be protected with a train moving from B to A the arrange-

ment will be the same only that the action of the stick relay is reversed. In Fig. 162 the same is accomplished in a different way. Here the clearing of signals 1 or 2 and the train entering track section A will drop the stick relay S and cause the locking

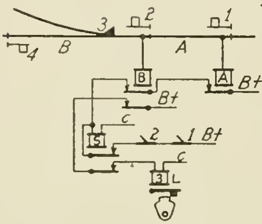


FIG. 162.

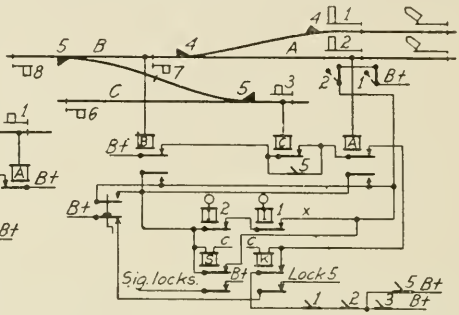


FIG. 163.

of lever 3. A train moving in the opposite direction will not drop the stick relay owing to the stick circuit being broken through levers 1 and 2, but the lock will be de-energized as it is controlled through track relay B.

Example of Complete Protection. In Fig. 163 the layout will necessarily consist of three track sections to take care of the section and route locking. Two approach indicators are required so that the towerman will know on which track the train is approaching the plant. Stick relay S will act as an approach and indication locking medium by dropping as soon as either signal 1 or 2 is clear and when a train is approaching on either track. Attention will be called to an error often committed in an approach locking circuit and that is, wire X, which is the pick-up wire for the stick relay, is eliminated and the stick relay connected direct to battery positive through the approach indicator contacts. This will mean that the stick relay and consequently the lever lock is released with the picking up of the indicators regardless of the position of the signals. The stick relay S controls half reverse locks on the signal levers. The release is accomplished through the screw release and back points of track relays A and B. Route and section locking is provided by track relays and stick relay K. The signal lever locks will keep the route locking in effect until the train has entered onto section

A when the signal lock is released. Here the route and section locking takes effect by track relay A locking lever lock 4 and also by dropping relay K, which again controls lever lock 5. Stick relay K is the locking relay for track section B in that it will also drop if signal 3 is cleared with switch 5 reversed and a train entering track section C. A relay similarly controlled will be necessary also for section C for the clearing of signal 8 with 5 reversed.

Application of Lever Locks. Since the similarity of stick locking and approach locking lies in the fact that no locking shall be effective without the clearing of a signal it follows that in both styles the most favorable and simple arrangement is to place half reverse locks on the signal levers and in many cases, as for instance where no stick relay is employed, it is not possible to apply the locks to any other levers. As an example, suppose a train in the approach section should lock up a route where only derail and switch lever locks were employed, these levers would be locked even if the signal was not cleared and the leverman would be powerless to line up routes except by using a screw release. Here approach locking would have defeated its own purpose. As in the last figure discussed, by the employment of a stick relay, approach locking is provided without any additional locks other than those employed for indication locking purposes. It will be evident, however, that a number of different styles of locking can be applied to an interlocking plant without combining the various kinds of protection. This is advantageous from a designer or maintainer's point of view because by separating and consequently simplifying each circuit, a less complicated, and a circuit in which trouble can readily be located, will result. On the other hand, from an economical point of view an arrangement as mentioned is not always advisable.

IX

SECTIONAL ROUTE LOCKING

Definition. Sectional route locking is the nomenclature substituted by the Railway Signal Association for the previously termed release route locking, and is defined as follows: "Route locking, so arranged that a train, in clearing each section of the route, releases the locking affecting that section."

As its name implies, sectional route locking is an extension or further development of section locking and route locking combined. In addition to section locking, route locking is provided which, through the medium of track circuits, locks all levers or sections governing switches in any particular route when the train passes the signal governing that route. Each of the switch levers or sections is released as soon as the rear end of the train has passed over the switch and is clear of the fouling limits of the switch leads or passed out of the section in which the switch protected is located. The releasing of switches in the rear of a train in the manner as set forth permits of the maximum number of train movements at maximum protection and the employment of this style of locking is mostly restricted to larger terminals and yards where congested traffic makes the arrangement necessary. Besides the advantage of having portions of a route released as a train passes beyond them while leaving those portions in advance still locked it is obvious that in this way the traffic may safely be facilitated through large terminals without the use of a great number of signals.

Requirements. 1. Sectional route locking should be made effective with trains running in one or both directions over a given piece of track.

2. The locking may become effective with the train entering the first section of a route with a signal at clear only or with a signal at clear or danger.

3. It can be arranged so that the release will take effect only upon the restoral of the signal lever normal at any predetermined time or as the train is passing out of each track section.

4. In all applications of sectional route locking, section locking must under all circumstances be effective.

Since sectional route locking in most cases is applied to interlockings protecting large, complex and congested track layouts, it follows that the circuits employed often become rather complicated when viewed as a whole. For this reason a sectional route locking circuit should be thoroughly analyzed and the various elements comprising the protection separated into its various components. With this in mind, a circuit providing sectional route locking will prove to be a more simple problem than at first anticipated, and it will be attempted in the present article to separate and designate each wire for the control of the various elements and, where possible, show the circuits in separate diagrams.

Various methods may be employed to accomplish sectional route locking, and to distinguish one from the other each one will be designated scheme A, B, etc. The main principles of each scheme will be presented by simplified track layouts, switches and turnouts being eliminated to avoid undue complication in the circuits. In the schemes first discussed more detailed description will be presented, as it will lead to a clearer conception of the following systems of which less detailed diagrams will be shown. It might be stated that of the many systems to be described some have the merit of being original.

SCHEME A.

Description. One of the principal elements involved in sectional route locking will appear quite simple when referring to Fig. 164, in which the locking is effective in one direction only.

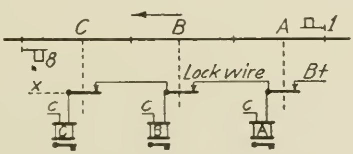


FIG. 164.

The layout selected shows three track sections A, B and C, with no switches, the layout without these serving the purpose equally well. It is to be assumed, however, that each track section protects one or more switches, the control of the switches being protected either by means of lock relays or lever locks. The sectional route locking is assumed to take effect with a train

movement in the direction of the arrow whether a signal is cleared or not.

Diagrams. In order to explain intelligently the application of the different systems to various combinations of signals and routes, it will be necessary to present all diagrams in a simplified form, in which the tracks are represented by a single heavy line and the track relay by a dotted line running to the track section by which it is controlled. Contacts on these relays are represented by a regular relay contact symbol crossing the dotted line, which is the relay by which it is controlled.

Lock Wire. Only one wire is necessary in the present system and, being utilized in the control of the locks, will be designated "lock wire." Locks A, B and C will all become de-energized with the dropping of track relay A; the dropping of track relay B and picking up of track relay A will keep locks B and C de-energized, but lock A will be released, and so on. A train moving in the opposite direction to the arrow will only de-energize lock C when entering track section C; de-energize C and B when entering section B; and de-energize locks C, B and A as long as it remains in track section A. It will be evident that a train first entering track section A will lock up all the switches ahead of it and release each lock as it passes out of the section, while a train moving in the opposite direction will only lock the switches as each section is entered and keep all the switches in the rear locked up until the train has completely passed out of the route. The dotted wire X shows a continuation of the lock wire should the route be extended beyond the limits shown.

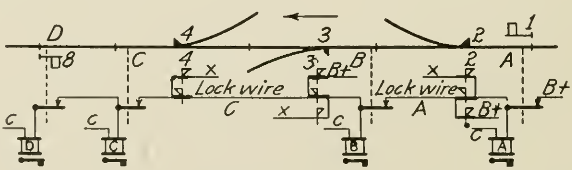


FIG. 165.

Selections. Fig. 165 shows the same scheme with switches included in the track layout, so as to take care of converging and diverging routes. The switches in this and the following diagrams are located with a view to covering the various com-

binations most likely to be met with in practical track layout arrangements. No fouling circuits or other track circuit details will be shown. The selecting contracts are shown located opposite the switch, although it should be evident that the contacts employed are located on the levers operating the switches, as it would be of prohibitive cost to have the selections made outside of the tower. The track relays, where sectional route locking is employed, are generally located in the tower, or repeaters controlled by the track relays when such are used.

Lever lock A gets positive battery through track relay A at all times. Selections on switch 2 are necessary, because when switch 2 is normal battery should feed the locks ahead through track relay A. If 2 is reversed the locks controlled by track sections B, C and D should not be deprived of positive battery, as this would prevent the lining up of parallel routes. Thus the wire marked X will be connected with locks and break through track relays located in the route governed by signal 1 when switch 2 is reversed. Following lock wire A through track relay B, this wire is selected on switch 3. The reverse contact on switch 3 will feed through wire X, the locks in the route governed by signal 1 with switch 3 reversed and the normal contact on switch 3 will feed lock C through 4 normal and track relay C. If 4 is reversed locks C and D will get battery through the relays for track sections on turnout 4.

Applications. As pertaining to scheme A the following should be observed in its application: (a) The lever locks should receive energy from one direction only. (b) The lock wire should be selected so that the throwing of a switch lever will not deprive a lock of current. (c) All selecting contacts should be arranged to make before break. (d) There must be a separate lever lock for each end of a cross-over. (e) A lever lock shall always break through a track relay. (f) Lever locks should be employed as a locking medium.

Comments. While the advantage of the present scheme is its simplicity, the disadvantage lies in the difficulty of making lock wire selections when lock relays are employed. If, for instance, in Fig. 165, the selecting contacts on switch 3 are made full normal and reverse contacts, the reversal of levers

3 and 4 at the same time would momentarily interrupt switch 4 control circuit. Should contacts on lever 3 be arranged to make before break lever 3 could be placed in the center position and a train having entered track section A would not lock switch 4, because lock relay 4 would get current through lever contacts 3 reversed. Another disadvantage is present at layouts where the route wire overlaps an opposing signal. A track layout of this kind is shown in Fig. 166. The route wire, assuming the

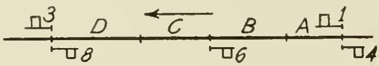


FIG. 166.

sectional route locking to be effective with a train running in the direction of the arrow, will have to run from section A past signal 6 to section D. By so doing a train running in the opposite direction to the arrow will tie up the route between signals 6 and 8 when standing ahead of signal 4.

SCHEME B.

Description. This scheme is similar to scheme A, the difference being that sectional route locking is effective in both directions. Fig. 4 shows a simplified track layout to which a circuit typical of scheme B is applied. In this scheme stick relays are employed for the selection of the direction of traffic. To simplify applications at complex layouts, the circuits should be divided into stick wires and route wires.

Stick Wire. The stick wire is the wire which goes from battery positive to K via signal lever contact and stick relay contact. This wire should break through normal contacts on one or more signal levers and select on switch levers so as to shunt out those signal contacts which would interfere with the clearing of signals in non-conflicting routes.

Route Wire. The route wire is the wire between the stick relays or from K to K. This wire is selected on switch lever contacts as in scheme A and breaks through the track relays between opposing signals. Since each lever lock in the present scheme under normal conditions receives energy from two direc-

tions, it follows that each side must break through a contact on the same track relay for section locking protection. Thus it will be noted that each lever lock is connected to the heels of two relay contacts, and this must be adhered to whenever the present scheme is applied in a circuit. These contacts must also be connected in series with the route wire. Each end of the route wire is in most cases broken through a stick relay, which relay again should be controlled through contact on signal levers on the opposing signals at the opposite end of the route to be protected. It will be found that in cases where the selections made will result in the route wire being controlled by all the track circuits in the route the route wire need not go through a stick relay to battery.

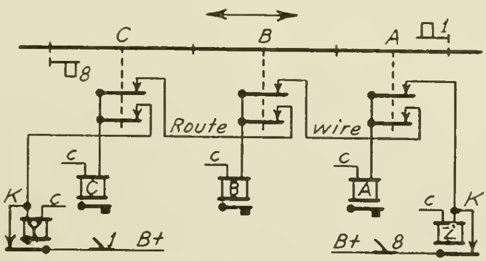


FIG. 167.

OPERATION. Assume a train in Fig. 167 to run from signal 1 toward signal 8. Signal 1 having been reversed will remove battery positive from the Y stick relay end of the circuit and current will be supplied to all the lever locks through stick relay Z and lever 8 only. When the train enters track section A the current is entirely cut off all the lever locks and stick relay Y by the dropping of track relay A. Stick relay Z, however, will stick up through lever contact 8. The train clearing track circuit A will reapply current to locks A through stick relay Z, while locks B and C will remain de-energized owing to the train's presence in section B. The same process will re-occur for each section in sequence as the train passes out of one into another. It will be evident that the restoral of a signal lever after the train has entered the route will not release the route ahead of a train as the stick relay cannot pick up again until the train is entirely out of the route. The same operations will

take effect upon a train moving in the opposite direction. In Fig. 168 switch lever selections are included in a layout similar to Fig. 165. The explanation covering the selection of the lock wire in Fig. 165 will apply to the route wire in the present figure. In the previous figure only two contacts on lever 4 were necessary, while in Fig. 168 three are employed. It will be evident

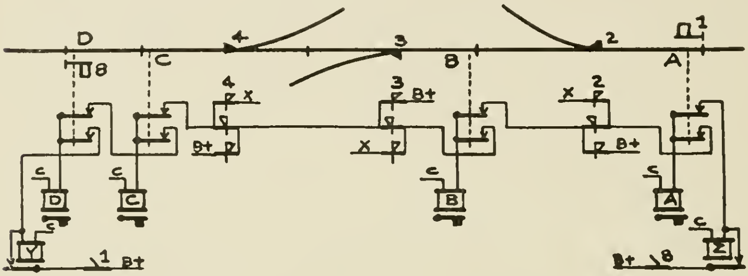


FIG. 168.

that the additional contact is necessary in scheme B because positive battery should be applied to a route wire in both directions. Locks B and A will be fed positive battery through lever 4 reversed, and locks C and D will take battery through other track relays and stick relay controlled by lever 8 when switch 4 is reversed. In view of previous discussion, other parts of Fig. 168 should be self-explanatory.

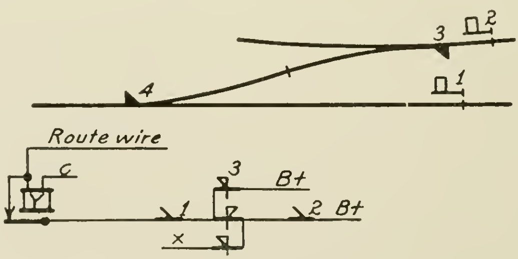


FIG. 169.

Stick Wire Selections. An example of a stick wire selection is shown in Fig. 169. The stick relay Y will take care of train movements with signals 1 or 2 cleared. The relay is made to stick through signal levers 1 and 2 in series but when switch 3 is normal contact on 2 is shunted out. In this way with lever 3 normal signal 2 cleared will not interfere with stick relay Y but will control other stick relays through wire X.

Route Wire Selection. In Fig. 170 the stick relays governing train movements by signals opposing signals 1 and 2 are shown. Here two stick relays are necessary to care for parallel train movements. Stick relay Z1 will connect to route wire W with 4 normal, with 4 reversed it will connect directly to positive battery. Stick relay Z2 will connect with route wire X when lever 3 is normal, and with 3 reversed and 4 normal, will connect directly to positive battery; but with 3 and 4 reversed will connect with route wire W through track relay A. With 4 reversed stick relay Z1 need not break through track relay A because 4 is a trailing switch which, when reversed, prevents the clearing of

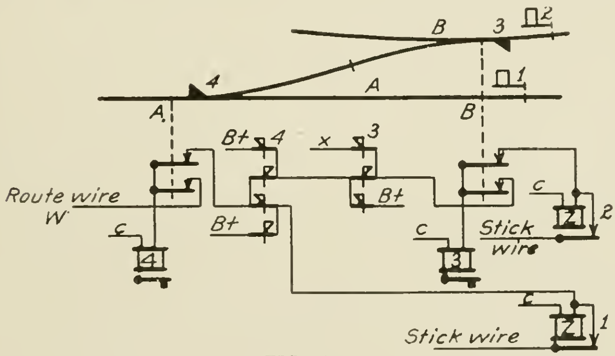


FIG. 170.

signal 1. Whether 3 is normal or reversed, stick relay Z2 must break through track relay B at all times because switch 3 is a facing point switch.

Applications. In addition to remarks as to applications of scheme A the following may be added for scheme B: (a) A stick relay must be provided at the outgoing end for each route. (A section of tracks where trains run in both directions is considered as two routes.) (b) Normally the lever locks should receive energy from two directions. (c) In the present scheme it will be to advantage to designate the stick relay with letter S and suffix the track circuit letter or number of the end track circuit.

Comments. While the application of scheme B requires a limited number of track relay and lever contacts, a disadvantage

will be found in certain track layout and signal arrangements when the circuits will become very complicated. Also lock relays cannot be employed for reasons set forth in the discussion of scheme A.

SCHEME C.

Description. In the present system one stick relay only is employed for the signal governing a movement in one direction while the opposing signal has no stick relay. The stick relay is normally de-energized and with the clearing of one signal this relay will stay down while the clearing of the opposing signal will energize the stick relay. The lever locks are controlled through the front and back points of the stick relay and in this manner the energized or de-energized state of the stick relay will select the direction in which the electric locking shall be effective.

The circuits are divided into two general classes, the stick relay circuits and the lever lock circuits.

Stick Relay Circuit. Fig. 171 shows the stick relay circuit

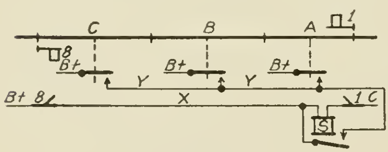


FIG. 171.

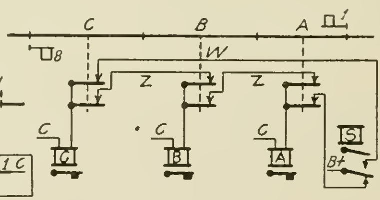
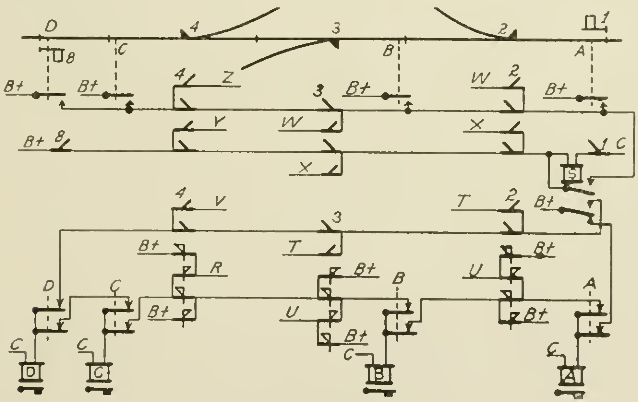


FIG. 172.

applied to a simplified track layout and the circuit is composed of two parts, the pick-up wire X which breaks through lever 8 reversed, and the stick-up wire Y which is controlled through back points of all the track relays in the route in multiple. Stick relay S will pick up if signal 8 is cleared and stick up through the stick wire Y while a train is occupying the track sections in the route. With lever 1 reversed the stick relay will remain de-energized. It will readily be seen that restoring one signal to normal position and clearing the opposing signal will reverse the position of the stick relay and consequently reverse the sectional route locking.

Lock Circuit. In Fig. 172 the lock circuit is shown as applied to the same layout as in previous figure. The lock circuits are composed of two parts, namely, the battery feed wire W and the lock wire Z. The lock wire receives battery from a back contact of the stick relay while battery is fed to the other end of the route over the battery feed wire through the front point of relay S. Thus, it will be seen that when a train is going in the direction when the stick relay is energized, battery is fed behind the train as it proceeds. When the train is proceeding in the opposite direction the stick relay being de-energized, the current is also fed from behind the train. The lock wire from either side is also controlled through a front point on the track relay of the section in which the switch is located, thus providing absolute section locking. It will be evident that by combining the stick relay and lock circuits the switches and derails will always be locked ahead of and under a train while those behind a train will be unlocked.



FIGS. 173a and 173b.

Operation. Referring to Figs. 71 and 72 the operation will be as follows: The reversal of lever 8 will pick up stick relay S and the relay will stick up through back joints of the track relays in the route. The picking up of this relay will cut current supply from lock wire Z and the locks will be fed through battery feed wire W, through front point of stick relay S and front point of track relay C. A train entering track section C will de-energize all the lever locks, but a train having passed from section C onto section B will energize lock C, and so on. The clear-

ing of signal 1 will feed all locks through the back point of stick relay and through front point of track relay A.

Selections of Stick Relay Circuit. In the track layout in Fig. 173a the pick-up wire is selected on switches 2 and 3; if either one is reversed the X wire will select on other switches and through the lever contact on an opposing signal. Wire Y which is connected to reverse contact on switch 4 will go to a stick relay which controls the route locking for the signal opposing signal 8 when switch 4 is reversed. Stick-up wire is selected so as to connect with other relay back points through wire W when 2 or 3 is reversed. Wire Z is a pick-up wire for an opposing route stick relay.

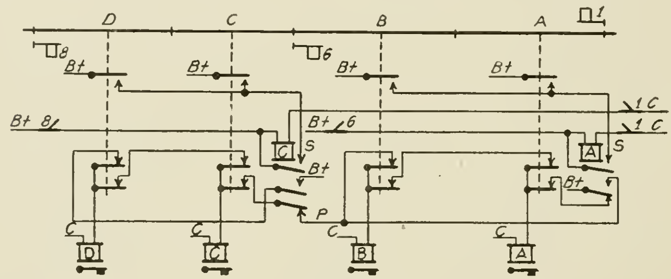


FIG. 174.

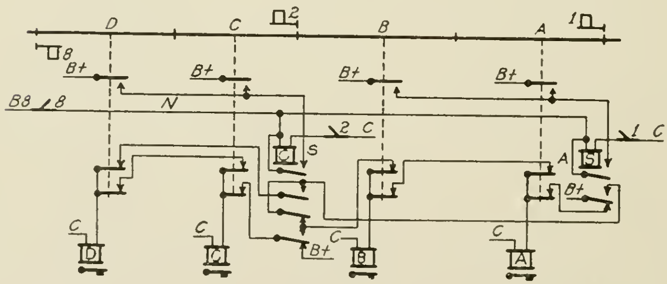


FIG. 175.

Lock Circuit Selections. In Fig. 173b the lock wire and battery feed wire selections are shown. The battery feed wire is selected on levers 2 and 3 so as to feed other locks through wire T if either one is reversed. The selection on lever 4 is made so that locks will receive energy through other stick relays by connection V. Lock wire is selected on levers 2 and 3 to connect with other track relays by connection U and to feed locks D and

C when switch 2 or 3 is reversed. Wire R will connect to battery through other stick relays. Figs. 174 and 175 show layouts with signals added to the diagrams. In Fig. 174 two stick relays are required and an overlap lock wire P is necessary. In Fig. 175 the same number of relays are required and an overlap pick-up wire N is necessary. In view of previous description these figures should be readily understood.

Applications. Most of the previous remarks as to applications will also apply to this system and in addition the following might be said: (a) Only signals governing movements in one direction have stick relays connected to them. (b) The stick-up wire should be selected through switches and controlled through track relay back points so that at no time will battery be disconnected from the stick relay while the train is occupying the route between the signals. (c) The battery feed wire and lock wire should be selected so that with a different line-up of switches the current is always applied to the locks through either a front or a back point on a stick relay.

Comments. The only disadvantage in this scheme is the dependence which is placed upon the stick relay without an automatic check being made on its operation. Should this relay, for instance, remain de-energized no sectional route locking will be provided with train movements in one direction and should it stick up the opposite direction will be without route locking.

SCHEME D.

Description. This scheme is very much like scheme C except that in scheme D the stick relay is normally energized and

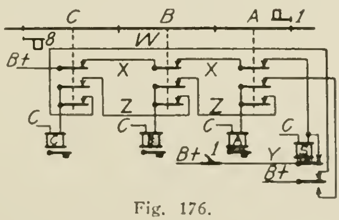
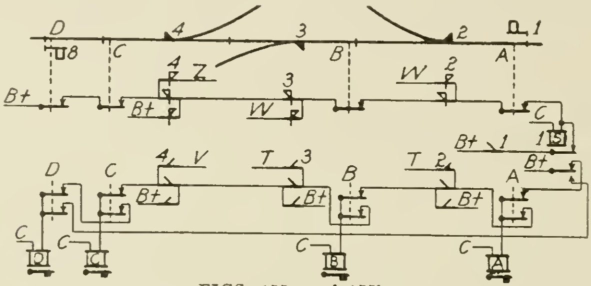


Fig. 176.

only controlled through one signal. The wires can be designated as in the previous scheme, W being the battery feed wire, Z the lock wire, Y the stick-up wire and X the pick-up stick re-

lay wires. Fig. 176 shows the application of the system. It will be noted that stick relay S will drop if signal 1 is cleared but with signal 8 cleared it will not drop until the train has entered track section C when the locking will take effect. Figs. 177a and 177b show the application and selections necessary in scheme D



FIGS. 177a and 177b.

and, being so closely related to the previous scheme, no further comment should be necessary.

SCHEME E.

Description. This scheme is similar to the foregoing. Here, however, one stick relay is employed for each route, or rather one for each signal. In this way the objectionable back point lock control is eliminated. Figure 178 shows the application of

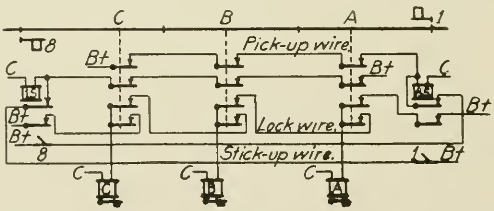


FIG. 178.

this system and it will be noted that a separate stick and pick-up wire is used for each stick relay, while only one lock wire is employed which is connected to positive battery at each end of the route through the stick relay governing opposing train movements. The clearing of signal 1 will drop stick relay 1S when a train enters track section A while stick relay 8S will remain energized. The dropping of stick relay 1S will cut off the current supply for the locks at this end of the circuit; and the drop-

ping of track relay A when the train enters that section will cut off current from the other end, thus depriving all lever locks ahead of the train with current. Because locks in section A get current through front point of stick relay 8S it follows that locks A will be released as soon as a train is out of Section A.

Applications. The following directions should be observed in connection with the present system: (a) One stick relay should be provided for each route. (b) Of the two stick relays employed for the electric locking of one piece of track either one must always be energized. (c) The stick relay pick-up wire and stick-up wire must be selected to take care of various line-ups and all stick wire selecting contacts should be arranged to make before break. (d) The lock wire should be selected the same as the pick-up and stick-up wires. (e) Both ends of the lock wire should go to battery through a stick relay point. (f) One lever lock is necessary for each end of a crossover.

Comments. This scheme will work equally well with lock relays as well as lever locks. The advantage lies in the elimination of the back point lock control and the few complications encountered when applying the circuit at large plants. The disadvantage lies in the additional number of lever locks and selecting contacts and the increased amount of wire required. When making comment upon complications in a circuit this does not refer to the work involved in the design of the circuit, but applies to the circuit installed and the trouble and tribulations of a maintainer when hunting causes for failures and the delays such failures will cause to traffic at the plant.

SCHEME F.

Description. In this system a stick relay is employed for each direction of traffic and for every track section beyond the first section in the route. Where a route consists of more than one track section, however, the last track section need not have a stick relay connected with it. It is only necessary that the lever locks be controlled through one or two of these stick relays in addition to the track relay for the section in which the switch is located.

OPERATION. In Fig. 179 it will be noted that stick relay marked BE (track section B for eastbound electric locking) will drop with lever 8 reversed when the train enters track section C. Hence a train moving with signal 8 at clear will de-energize C locks when entering track section C, and will also lock B and A

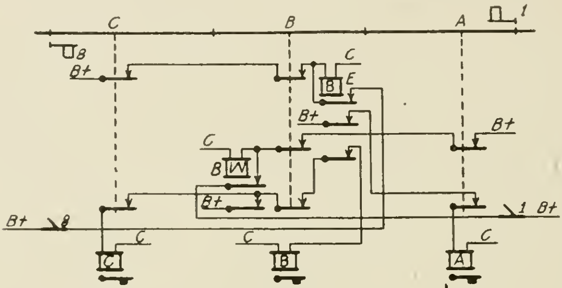


FIG. 179.

by the dropping of stick relay BE. A train entering B section will keep B and A locked, and a train entering section A will release stick relay BE, which will pick up. With a movement in the opposite direction signal 1 will be cleared and the train entering section A will drop stick relay BW while BE will stay up. The operation will be identical with the train movement

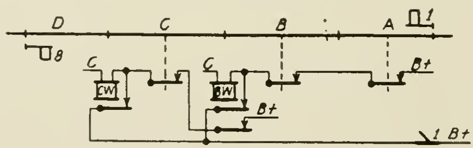


FIG. 180.

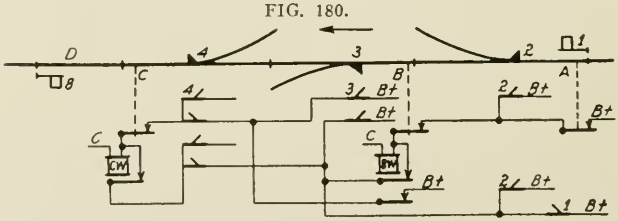


FIG. 181.

described with signal 8 cleared. In Fig. 180 westbound train movements will be protected by BW and CW stick relays and eastbound movements by CE and BE stick relays. The latter relays are not shown, as their control will be similar to that indicated. Fig. 181 shows the selections for stick relay pick-up

and stick-up wires. The sectional route locking is assumed to be effective with signal 1 cleared, while for electric locking in the opposite direction the arrangement will have to be duplicated. Westbound stick relays are required for track sections B and C, as shown, and the same for eastbound train movements. Selection whereby BW is shunted out of track section A and signal 1 when switch 2 is reversed is necessary. CW relay can be controlled through BW stick relay instead of the track sections and can shunt out when 3 is reversed. With lever 4 reversed CW will be controlled by other signals and track sections, as explained in previous systems.

Applications. In regard to how to apply the present system the following will be of value: (a) Every section in a route except the first and the last section will have two stick relays. The stick wire for each is to be controlled through a signal lever and selected through switch levers, and the pick-up wire is to be controlled through all sections in advance. (b) The stick relay must not drop when manipulating any lever on which it is selected. (c) Where a route consists of two track sections only the last section will have a stick relay. (d) Where a stick relay is employed for one section in advance of another the next stick relay can be controlled through a front point of this relay instead of through the track relays. The locks will take battery from one direction only through one or two stick relays and a track relay. (e) Only one lever lock is necessary for a cross-over. (f) Lever locks need not be selected.

Comments. For simplicity in design and on account of the limited number of selecting and track relay contacts required, the present system cannot be excelled, although the additional number of stick relays required when a route consists of a considerable number of track sections might be considered a disadvantage by some engineers.

SCHEME G.

Description. Like the scheme just described, scheme G employs one stick relay for each direction, and for each section following the first track section. In the present system, however, the stick relays drop when the signal is cleared and do not

pick up until the train has entered the track section in which the lock to be released is located. This scheme is arranged on the order of a stick locking circuit in that the locking takes effect upon the clearing of a signal whether a train enters the route or not.

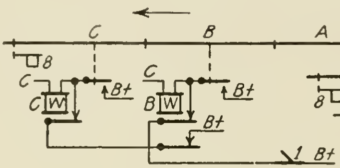


FIG. 182.

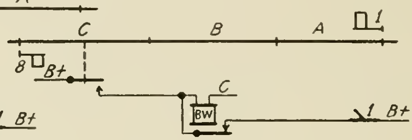


FIG. 183.

Operation. In Fig. 182 the scheme is shown applied to trains running in the direction of the arrow. It will be noted that the clearing of signal 1 will drop stick relay BW, which again will drop CW relay. A train entering section B will pick up BW stick relay and upon entering section C, CW relay. For train movements in the opposite direction a stick relay for sections B and A, designated BE and AE, will be necessary. By controlling locks A through stick relays BW, AE and track relay A; locks B through BW, BE and track relay B; and locks C through CW, BE and track relay C, sectional route locking and stick locking will be provided for train movements in both directions. The stick relay circuit can be arranged as shown in Fig.

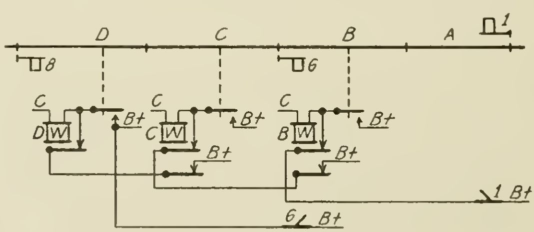


FIG. 184.

183. Here only one stick relay (BW) is necessary for one direction, this stick relay picking up in track section C. With this arrangement, locks in section A cannot be controlled through the stick relay, as they would not be released until section C was reached by the train. Thus the dropping of BW relay when

clearing signal 1 would not drop locks in section A, but these locks would be de-energized by the train entering section A. The locks in C would be controlled through relays BW and BE in series. With the circuit as arranged in Fig. 18, but with a different layout, the circuit for a train movement in one direction will be arranged as in Fig. 184. No description should be necessary except that the reverse lever contact 6, which is used in multiple with pick-up circuit for stick relay DW, is employed so that stick relay DW will pick up even if a train, moving under a clear westbound signal, should stop ahead of signal 6 without entering track section D. Hence the clearing of signal 1 will drop stick relay DW, and, if the train stops ahead of signal 6 for a back-up movement, the clearing of this signal will again pick up stick relay DW. The application should readily be understood from the description made.

Comments. The advantages of system G are: (1) the requirements of few selections and track relay points, and (2) the simple manner in which the circuits can be arranged. The disadvantage is the apparent inconsistency when considering that section route locking is applied to an interlocking to improve flexibility and facility in train operations. Should the leverman in the present system clear a wrong signal the route would be tied up until the manipulation of a time release would again restore the plant to normal operating conditions. There are many engineers, however, who rightly insist upon procuring the protection given by stick locking in all applications of electric locking at interlockings under their jurisdiction and who keep the leverman responsible for any delay to train movements caused by errors on his part.

SCHEME H.

Description. Scheme H, which is another stick locking arrangement method of securing sectional route locking, employs two stick relays for each route. Both relays will drop with the clearing of a signal, one stick relay picking up on the first track section in the route, and the other on the last section. The arrangement will have to be duplicated for protection to train movements in the opposite direction.

Operation. Fig. 185 shows a circuit applied to a train movement in the direction of the arrow. The present circuit can only be applied to interlocking plants where lock relays are employed as a locking medium. With the clearing of signal 1 both stick relays 1S and 1SX will drop in turn all lock relays for sections

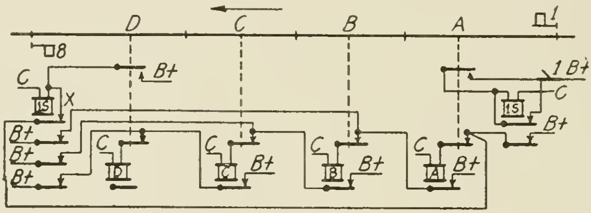


FIG. 185.

A, B, C and D. A train entering section A will pick up stick relay 1S, while stick relay 1SX will remain de-energized. When a train clears track section A current will be applied to lock relay A through stick relay 1S, the same process re-occurring for each of the sections in sequence. Stick relay 1SX will pick up in section D. It will be noted that each lock relay is controlled through a point on another. For this reason a train moving in a direction opposite to the arrow would keep the lock relays behind it de-energized as it moved along. By the employment of stick relay 1SX this is prevented, because when a train enters the

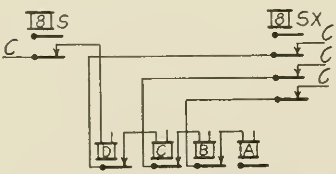


FIG. 186.

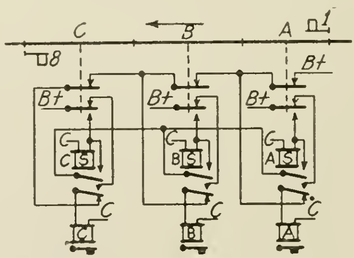


FIG. 187.

route with signal 8 at clear, stick relay 1SX will stay picked up and each lock relay will be connected to battery through a front point of this relay is multiple with the lock relay ahead of it. For sectional route locking, with signal 8 at clear, two more stick relays would be required, both controlled in the same

manner as the stick relays in the figure, except, of course, that lever 8 would drop both relays, and one would pick up in section D and the other in section A. The lock relays should take common through the stick relays and other lock relays in multiple, as shown in Fig. 186.

COMMENT. The same comments as made with the previous scheme will also apply to the one under discussion. It is evident that this scheme, with a few modifications, can also be applied to a plant in which lever locks are employed.

SCHEME J.

DESCRIPTION. A stick relay for every track section is necessary in scheme J. Each stick relay will pick up as the train enters the section to which it is applied, and the locks by receiving battery through a front point of the track relay and the stick relay will be released as the train passes out of each track section.

OPERATION. Fig. 187 shows a simple application of this system for a train movement in the direction of the arrow. A train entering section A will pick up stick relay AS for this section. The train clearing section A and having entered section B will pick up stick relay BS, which in turn will stick up relay AS through front point of BS and AS. Lock A will be released through front point of track relay A and stick relay AS. With the train in section C, all the stick relays will be energized. A train having cleared the route will again drop the stick relays. With certain modifications the system can be made applicable for sectional route locking in both directions.

COMMENTS. The advantage in this system is that section 31 route locking will take effect when a train enters a route with a signal at clear or danger. The disadvantages are the number of stick relays required, and the complications which a complex signaled layout will offer in the design and maintenance of the system.

FLEXIBILITY OF MECHANICAL LOCKING

Closely associated with sectional route locking the mechanical dog locking in the interlocking machine must be sufficiently

flexible so as to allow the releasing to be effective while also rigid enough to give protection to the trains. Thus in many installations where sectional route locking is applied signal locking only is employed, that is, signal levers lock all switches and derails in their route; the switch levers do not lock any levers, and the derail levers only lock derails in conflicting routes. In other installations the derails lock all facing point switches in the route, thereby allowing the line-up of any diverging route after the train has passed the derail and the facing point switch. At other places the high speed facing point derails will lock all switches and derails in the route, thereby providing flexibility in following high speed movements, but not in slow speed movements. In other places the derails are used for locking of routes while at the same time the system of locking is devised so that the flexibility in lever operation allowed by the electric locking is retained. This can be done by having the facing derail lock all the trailing derails and facing point switches in their route. In most installations where special release is required the mechanical locking is transferred from the derails to the signals to allow necessary freedom. The protection which may be lacking by the absence of switch locking is generally provided by having the signals controlled through all conflicting derails with certain line-up of switches to insure the proper operation and correct position of such derails. At mechanical plants it is important that the levers for the operation of the facing point locks are arranged with due consideration to the facilities of release which the electric locking will provide.

ADJUNCTS.

Lever Lights. Sectional route locking being applied at interlocking plants having congested traffic, it is of advantage to indicate the occupancy of a track section or the electric unlocking of a switch to the leverman. This can be accomplished by placing a small light on the top of each switch lever and having it controlled in multiple with the lever lock, showing at all times whether the lock can be energized or not. When the light is burning the track is free, but when the light is out the track is occupied and the lever must not be moved. If it is desired to use lights on the signal levers to show when the routes controlled by those signals are unoccupied, a light may be placed in series

or in multiple with the stick relay controlled by the signal and used in the sectional route locking, or a relay may be so placed to control the light.

Emergency Release. In sectional route locking emergency releases or time releases, as employed in connection with section and route locking, cannot be employed as it would tend to introduce additional complications in an ordinarily complicated circuit. Hence if it becomes necessary to change a switch or a derail ahead of a train which has come to a stop, current is generally supplied to the lever locks by means of a push button or a snap switch. This switch is often located at a distance from the interlocking machine so that it takes two men to release a route, one to push the button or switch and another to throw the lever while the button is being held. The switch or button is of a style which will replace itself to the normal position if left after the release is accomplished and the releas circuit will not shunt out the track relay in which the train is standing.

Conclusion. When deciding upon what system of sectional route locking to employ a number of points must be considered, viz., cost of installation, complications in design, complications and possible traffic delay in maintenance, protection for following train movements and numerous others. In this limited space it is not possible to cover each system in detail as much as could be desired. It is believed, however, that this chapter will give the proper conception as to the virtues and drawbacks of a number of schemes from which poor features can be eliminated and good features added to make them suitable for the needs and requirements of various plants. In all schemes described it is of course possible to provide combined protection by adding features necessary for such protection. For example, stick or approach locking may be added to the sectional route locking by having the stick relay for the former control the stick relay for the latter. In a similar manner other classes of electric locking may readily be combined with sectional route locking.

X

CHECK LOCKING

Definition. Check locking, according to the Railway Signal Association's definition, is: "A method of interlocking, electrically, the levers in two adjacent interlocking plants to permit train movements between them to be made safely against the current of traffic and as the result of co-operation at the interlocking stations concerned." It will be recalled that one requirement at an interlocking plant, when arranging the dog locking in the machine, is to so interlock the two signal levers governing the movement of trains on a given piece of track as to prevent the simultaneous entrance of trains from opposite directions. In one machine this can readily be done mechanically, but where the levers to be interlocked are located in two separate interlocking machines placed in a tower a short distance apart, this cannot be accomplished mechanically but electrical means must be resorted to. Briefly, check locking shall prevent the simultaneous entrance of trains from opposite directions onto a piece of given track and insure that the operators in both towers are "working together," or insure the co-operation of levermen in two adjacent towers.

Where Employed. Check locking is employed at interlockings situated close together, (a) where the arrangement of switches and signals is such that it would be of advantage to make use of the same track under special conditions or (b) where local conditions such as tunnels, trestles or bridges prevent the construction of more than one track (or "gauntlet track") between two adjacent interlocking plants. Thus in the one case check locking can be employed to advantage to facilitate the operation of a large number of trains and add to the flexibility of two or more tracks between interlockings; in other words, it will readily accomplish the change of normal current of traffic with maximum safety at a minimum expense. In the second case it comes near being a substitute for single track controlled manual blocking and, in fact, this may be said to be true of any effective form of check locking.

Requirements. 1. Check locking should be made effective with the clearing of a signal, permitting the entrance of a train

onto a piece of given track which leads to an adjacent interlocking plant.

2. The check locking effect should be made permanent while the train is moving between the signals governing the opposing movements over the common piece of track.

3. Check locking can be made effective for train movements in one direction or in both directions.

There are, broadly speaking, two classes of check locking, viz.: (a) where it is applied to give preference as to direction of traffic and (b) where no preference is given as to direction of traffic.

With the Use of Check Lock Levers. In order that the simplest circuits with a limited number of instruments be obtained the best arrangement possible at large interlocking is with the use of an independent lever in each machine. The levers employed are generally termed check lock levers (also traffic levers and master levers) and to these levers the electric locking provided is applied. As a rule each track over which reverse train movements between the interlockings are to be permitted is provided with a check lock lever.

Arrangement of the Mechanical Locking. At interlocking plants where it is desirable to employ a separate lever in the interlocking machine, as a check lock lever, and where there is preference as to the direction of traffic, the mechanical locking in the interlocking machine should be arranged so that when the check lock levers are in their normal position the signal lever

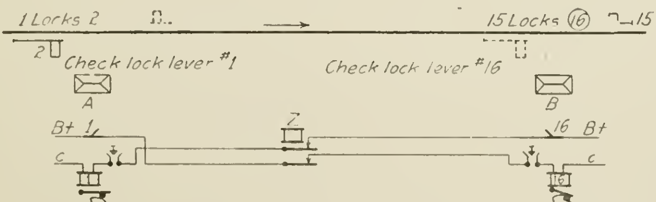


FIG. 188.

for the reverse movement should be locked normal and the signal lever for movements with the current of traffic should be free to move. When the check lock levers are reversed the

signal lever for movements with the current of traffic should be locked normal while the reverse movement signal (generally a dwarf signal) should be unlocked and in position to be cleared. The locking arranged in accordance with the above is shown in Fig. 188. This is a simplified layout showing a single track where the normal current of traffic is from tower A towards tower B. Here in tower A check lock lever 1 locks signal lever 2 normal and in tower B signal lever 15 locks check lock lever 16 reversed.

Where there is no preference as to the direction of traffic the check lock levers when in the normal position will lock the signals governing the opposing movements normal, while the check lock levers when in the reverse position will unlock the signal

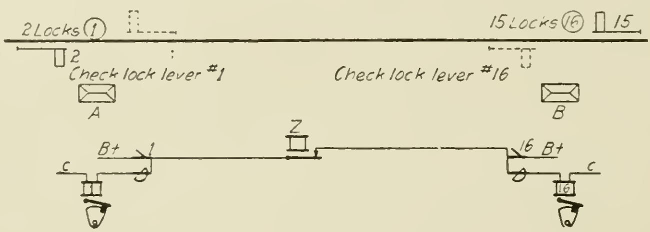


FIG. 189.

levers. This is illustrated in Fig. 189 where signal lever 2 locks check lock lever 1 (tower A) reversed, and a similar arrangement is made at tower B.

Traffic Direction Preference. Check locking, giving preference as to direction of traffic, is generally used in connection with two or more track systems. Fig. 188 shows a circuit giving traffic direction preference and as the normal direction is from tower A to B, as shown by the arrow, signal 2 is free to be cleared at any time without interference from the check locking. In order to clear signal 15, permitting a movement against current of traffic, the check lock levers in both towers must be reversed; lever 1 in order that lock on lever 16 can be energized and lever 16 in order that 15 can be released. With lever 1 reversed signal lever 2 is locked normal. The lock on lever 1 will necessarily be a reverse lock which will hold this lever locked until 16 is placed normal again. Lever lock on 16 is a normal lock which prevents the release of the lever until 1 is

reversed. Relay Z represents the contacts or combinations of selections taking place between the towers to prevent the release of the check locking until the route is completely traversed by the train. With the arrangement as shown it is evident that it is impossible to have a condition existing which would permit the two opposing signals 2 and 15 to be cleared simultaneously.

Another method with a traffic direction preference arrangement is the use of only one check lock lever in the direction of traffic and the opposing signal inter-connected electrically with the check lock lever. In Fig. 190 the stick relay C at tower B

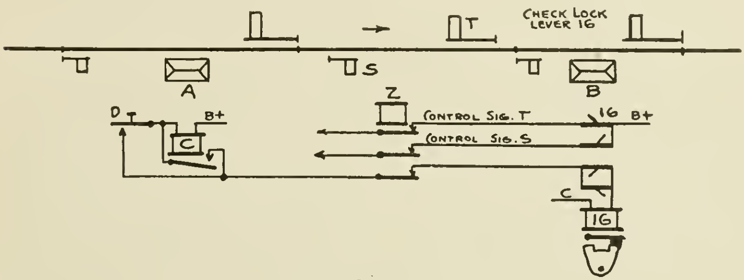


FIG. 190.

will make cooperation between the towers compulsory, as the pressing of the hand key D and energization of relay C will admit the complete reversal of check lock lever 16 in tower B. The operation of signals T and S can only be accomplished with the completion of the movement of lever 16 in either direction, as shown.

No Traffic Direction Preference. Fig. 189 shows a circuit where there is no preference as to direction of traffic and this scheme is employed at single track roads or tracks being of gauntlet construction or in a tunnel. Here, in order to clear signal 2, check lock lever 1 must be reversed and in order to reverse lever 1 check lock lever 16 (tower B) must be normal. By reversing lever 1, lever 16 is locked normal and consequently levers 1 and 16, and again levers 2 and 15 cannot be reversed at the same time. Locks on levers 1 and 16 are full normal locks and Z relay represents the track sections between signals 2 and 15.

Tower Director Control. At places where directors are employed to supervise the handling of trains it is important that

the circuit be arranged so that the check lock levers will not be released without their consent. A circuit including such a provision is shown in Fig. 191. This is a no-traffic preference scheme and the hand keys marked Y are the tower director's

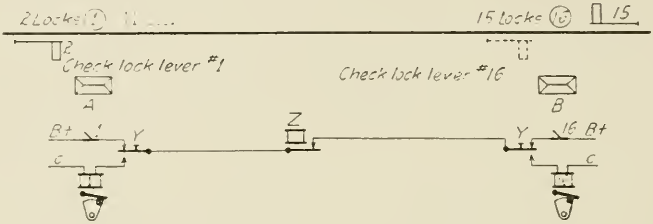


FIG. 191.

release keys. In order that check lock lever 1 (tower A) can be released the director must press the key Y and this will also remove positive battery from lever 16 at tower B. Additional lever contacts can be employed in this circuit as amplified in Fig. 189.

Without the Use of Check Lock Levers. The protection of a layout as in Fig. 189 can readily be accomplished without the employment of check lock levers. Fig. 192 shows such an

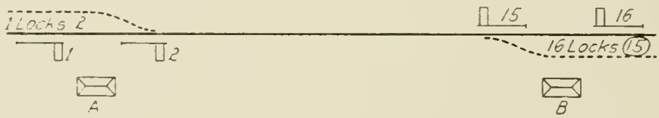


FIG. 192.

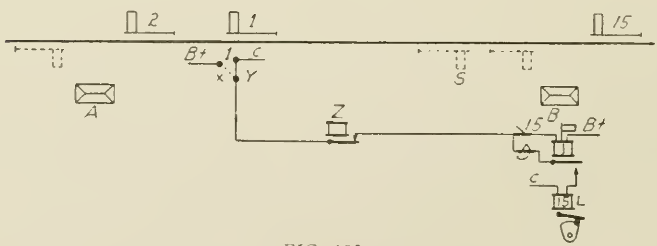


FIG. 193.

arrangement where advance signal levers 2 and 15 reversed are locked by the home signal levers, the advance signal levers thereby acting as check lock levers. A normal lock is to be placed on the advance signal levers and the locks controlled as in Fig. 189.

"Advance Signal" Arrangement. In Fig. 193 an arrangement is shown where the advance signal for interlocking B is used as a distant signal for interlocking and check locking is provided by the employment of a normal lock on home signal lever 15. The procedure, when permitting a train movement from B to A, will be that signals 2 and 1 are cleared from tower A. Signal 1 cleared will close contact X on signal circuit breaker and break contact Y. This will drop indicator I in tower B, thereby indicating to the operator that lever 15 is released. Lever lock 15 will take battery through contact X at signal 1, through all intervening track relays Z, contact on its own lever and back point of indicator I. The arrangement will have to be duplicated for a train movement from tower A to B, when signal S will be the advance signal and the other appliances be located in tower A.

Tower Lock Instrument. Check locking can also be provided through the medium of tower lock instruments or so-called electrically locked circuit controllers. These circuit controllers are employed to pick up relays which again act as control or slotting relays for the signals permitting the opposing train movements to take place. In Fig. 194, I and H are tower instru-

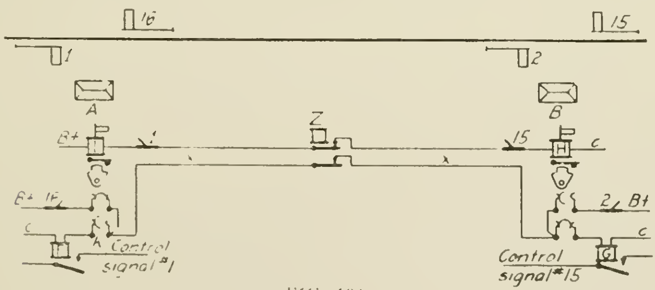


FIG. 194.

ments normally energized, and F and G relays used for the control of signals 1 and 15 respectively. In order to permit a train movement from tower B to A levers 1 and 15 must be normal. The clearing of signal 16, and with instruments I and H in the normal position, relay G will pick up. The reversal of lever 15 will clear this signal through a contact on relay G. As wire X is used solely for the purpose of energizing the control relays F

and G, this wire can be selected through switches, derails and track relays so that the signal control wire proper needs only to be broken through either relay. For a train movement from A to B, both tower instruments must be reversed and signal 2 reversed, when relay F will pick up through reverse contact L on instrument H and reverse contact K on I and wire X. The traffic preference is obviously from tower B to A.

At Power Interlockings. At power interlockings where check lock levers are employed the arrangement generally used is to control the indication magnet in the interlocking machine in the manner shown in Figs. 188 and 189. The special indication schemes employed at such plants are generally of necessity modified so as to actuate the indication magnet by a battery indication arrangement. The other schemes are also applicable to power interlockings.

Additional Protection. As an extra precaution the lock on the check lock lever may be controlled in series through contacts on all signal arms controlled by the interlockings, in addition to a contact on the signal lever, thereby insuring that all signals have assumed the stop position before the lever is released. As in other styles of electric locking the lever lock when placed on a signal lever may be modified and the circuit arranged so that section locking and indication locking will be provided in addition to the check locking.

XI

OUTLYING SWITCH LOCKING

General. Protection provided by the electrical locking of outlying switches can be defined as being electric locks controlled from a signal tower and attached to the operating connections of outlying switches to prevent a switch from being moved without the knowledge and consent of the tower operator or leverman. At mechanical interlockings it frequently happens that a switch or a crossover is located between the home and distant signal or between the dwarf and the advance signal, consequently close to the tower, but still too far to be safely operated from there with mechanical connections. At power interlockings, where the same conditions may exist, it might be found undesirable to take such outlying switches into the interlocking, due to the additional signals required. In all such cases the common practice is to lock the switches from the interlocking tower and have the trainmen operate the switch by means of a regular switch stand. The arrangement is to place the control in the hands of the leverman in the interlocking tower. He may thus, under certain restrictions, unlock the switch for the benefit of any train, provided conditions are right for its use.

Mechanical Arrangement. The earliest practice of such control of outlying switches at mechanical interlockings was to apply a mechanically connected bolt lock to the switch or lock it by means of a plunger lock, either one of which was operated from an interlocked lever. Such arrangements are also installed in the present day practice where the expense of more reliable protection is not warranted. When bolt locks are used the switches are generally equipped with front rods, lock rods and a usual bolt lock casting. The bolt lock rod is fastened to the switch point or the front rod and by means of notches in the two bars the switch can be locked and unlocked. The rods have only one notch each, so that the switch can only be locked in its normal position. In this way, when the switch is to be operated the leverman unlocks it, and he cannot again lock it until the switch has been placed in the normal position again. With a plunger lock the method of operation is the same. The switch is equipped with a lock rod and plunger stand, the lock rod being

drilled with only one hole, as previously discussed, whereby the switch is unlocked and locked only in one position. The arrangement of locking an outlying switch, with the use of a key, which is kept by the man in the nearest tower, has also been used to a limited extent. This method, however, is far from satisfactory, and causes too many delays to be practical on busy lines.

Electrical Arrangement. The electrical locking of an outlying switch can be accomplished in numerous ways. For instance, at the switch a one-lever dwarf machine may be provided, whose lever locks the switch in the desired position, and is in turn electrically locked from the tower by an electric lock. Another method is to use a special electric switch lock, which usually engages with the switch stand and, by preventing it from being operated, keeps the switch locked in the desired position. In other methods the electric lock will engage directly with the switch rails by means of suitable mechanical connections. This arrangement is possible when the lock is a combination electric lock and switch stand. Protection is generally provided by means of the lock rod, so that unless the lock rod assumes its proper position when the switch is set normal, the electric lock is prevented from assuming its normal or de-energized position. Electric switch locks are always provided with electrical contacts for the control of circuits which, in most cases, are employed to give an indication in some manner to the leverman that the switch has been placed normal and locked in that position. In the tower the electric switch lock might be controlled from a lever in the interlocking machine, which is interlocked with the other levers; or it might be controlled from a tower instrument or hand circuit controller, which is usually electrically locked by the switch lock.

Lever Locking. It is, of course, always most preferable to have the switch controlled from a lever in the interlocking machine so that the proper interlocking between it and the signal lever governing movements over the switch can be provided. Such levers are considered as F. P. L. Levers, and the switch lock control circuit is so arranged that the reversal of the lever will lock the switch while the placing of the lever normal will unlock it. The signal levers governing over the switch will lock the switch lock lever in its reverse position. Dwarfs and slow-speed signal levers, however, should not lock the switch

lock lever, as switch movements over the plant should be permitted even with the outlying switch lock released.

Hand Switch Control. A very simple outlying switch lock circuit is presented in Fig. 195. A hand switch "A" when

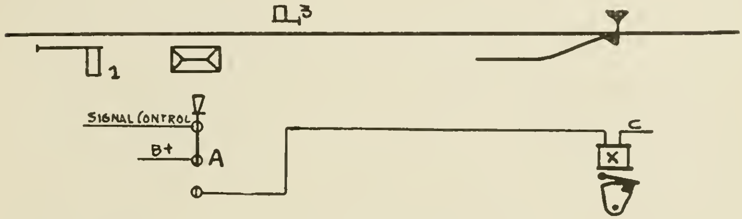


FIG. 195.

reversed will break the signal control circuit and release the switch lock X. The switch is equipped with a normal lock which prevents the release of the lock until the hand switch is thrown. A circuit of this type cannot give the protection required by many railroads, viz., prevent the placing of the signal to danger in the face of an approaching train and the immediate release of the switch lock. Furthermore, no provisions can be made to indicate to the leverman that the track switch has been placed normal again and locked in that position. By equipping the switch with a switch box and control signal 1 through a normal contact on same, protection to insure the track switch being placed normal is secured. With mechanically operated signals no protection against the simultaneous clearing of signal 1 and release of the switch can be provided.

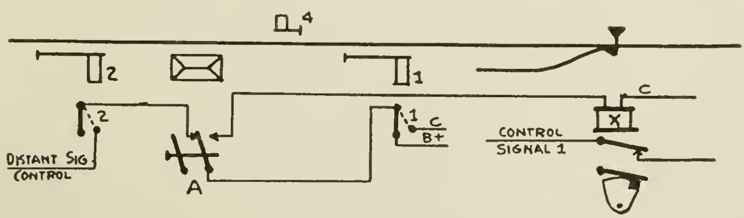


FIG. 196.

Another method of controlling an outlying switch lock by means of a hand switch or hand circuit controller is shown in Fig 196. In this track layout an advance signal is included to illustrate the combined protection usually provided. It will be

noted that circuit controller A when in the normal position will control the distant signal, this signal in the present case being arranged to give indication for signals 1 and 2. The reversal of controller A will break the distant signal control circuit and energize switch lock X, provided signal 1 is at danger. Signal 1 can only be cleared when the switch lock armature drops into the notch in the segment of the locking dog, and this can happen only when the track switch is in the normal position. Circuit controller A can also be used as an emergency switch for the release of any type of route locking by the use of the spare contact.

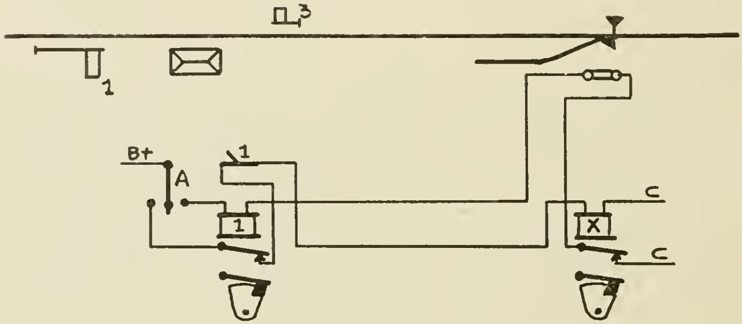


FIG. 197.

INDICATION WITH HAND SWITCH CONTROL. Fig. 197 shows a more elaborate scheme, which provides an indication to show that the track switch is locked in its normal position. Signal lever 1 is equipped with a normal lever lock of the type carrying contact springs on the lock armature, so that the switch can only be released when the lever lock is resting in the notched segment and, consequently, only when the signal lever 1 is normal. The outlying switch is also equipped with a normal lock which carries a contact spring which makes only when the lock armature drops into the notched segment of the lock dog. This contact, when made, will energize the lock on lever 1. While the switch is reversed the lock armature rests on the top of the locking dog and the contact is thereby broken. This insures that the switch must be put normal before the contact makes for the completion of the signal circuit.

Hand switch or key A has two positions, one of which will energize the switch lock provided lever 1 is normal, and the

hand switch in the other position will energize lever lock 1 provided switch lock X is normal.

LEVER LOCK CONTROL. As previously discussed, when a lever in an interlocking machine is employed to control the switch lock, the high speed signal lever should lock the switch lock lever reversed and, as the switch lock lever when normal unlocks the switch, the switch will be locked as long as the signal is at clear. There should also be some type of route locking applied to the high speed signal lever so that it will not be possible to take a signal away from an approaching train and immediately release the switch lock without a certain time interval. It is evident that one lever or one hand switch may be employed to unlock more than one switch and for this reason the circuit in Fig. 198 shows a circuit arrangement which will release two

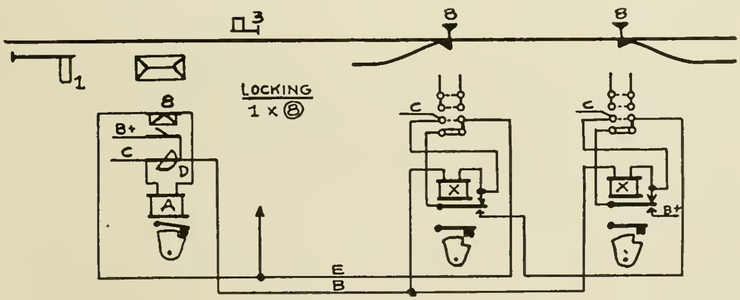


FIG. 198.

switch locks from one lever. It will be noted that the normal position of lever 8 will release the switch locks X through wire B, both switch locks being connected in multiple. The lever lock "A" which prevents the reversal of the lever unless the switches and switch locks are in their proper position, acts as an indication to this effect and indirectly prevents the clearing of signal 1 until the route is completely safe. Lever contact D acts as a cross-protection contact for the switch locks. The front contacts on the switch locks and the reverse switch box contacts are used as a cross-protection for lever lock A when the switch or the switch lock is in an improper position for the energization of the lever lock. The back points on the switch locks and the normal contacts on the switch box are used for the energization of the lever lock A. The tap on indication wire E can be em-

ployed for the control of signal 1 if this is power operated or controlled. In this way the signal will be provided with the same amount of cross-protection as that given the lever lock.

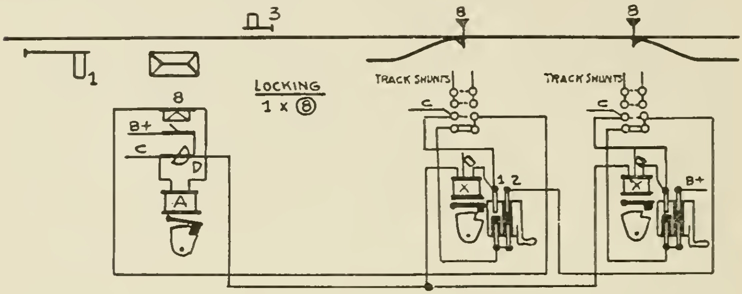


FIG. 199.

Fig. 199 shows an interlocked lever control of an electric lock placed on a dwarf lever machine. This type generally has a handle which can be turned only when the lock is unlocked while the handle will turn a commutator for the make and break of circuits. This type of lock also usually has a miniature semaphore arm which acts as indication of the position of the lock armature to the trainman. It will be noted that the control of the switch lock is identical with the previous figure and that the indication and cross-protection is provided in a similar manner, insuring the lever lock and commutator being in the correct position before the lever lock is released.

Tower Instrument Control. Where no space in the interlocking machine is available for the control of the outlying switches and where a more complete protection is desirable than that procured with the use of a hand switch, tower instruments are employed. These are electrically locked and equipped with a handle, the turning of which will make and break electrical contacts. For the locking and unlocking of the switch lock, tower instruments should be locked full normal and full reverse: full normal to prevent the instrument from being operated after a high speed signal is cleared, as the reversal of the instrument may place a signal at danger after having been accepted by an approaching train; full reverse to prevent the release of the instrument unless the switch and the switch lock are in their proper normal positions. In Fig. 200 lock magnet A on tower

instrument is normally de-energized and the commutator, operated by the handle, can be given a predetermined preliminary movement, just enough to make contact 1 provided signal lever 1 is in the normal position. The lock armature picking up will permit further movement of the handle to take place, which, in turn, will break contact 2 and make contact 4. Contact 2 is used for the control of signal 1 and contact 3 for the cross-protection of this signal when the tower instrument is reversed. Contact 4 is employed for the control of the switch lock while contact 5 completes a cross-protection contact when the tower instrument is normal. The contact B on lever 1 provides cross-pro-

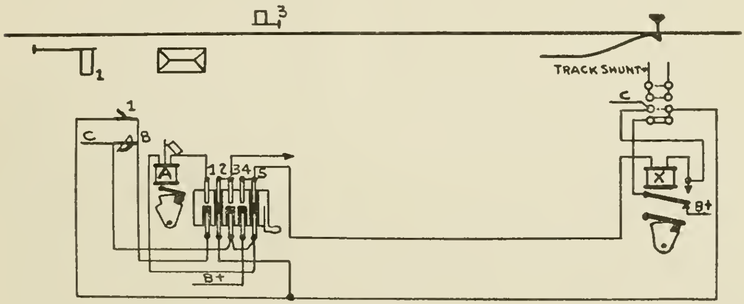


FIG. 200.

tection for tower instrument lock magnet when this lever is reversed. Previous discussion of the switch lock control and indicating features should be sufficient and no further comments necessary. Neither should the arrangements for other types of switch locks, as controlled from a tower instrument, need further comments. It should be observed that in all cases the cross protection contacts must break before the contro contacts make otherwise the battery will be short circuited during the operation of the lever.

At Power Plants. At power interlockings, in addition to the employment of regular switch locks and previously discussed circuit arrangements, dwarf signal mechanisms of the solenoid type or other specially designed high voltage devices are often installed. These mechanisms are controlled through regular interlocked levers and the same method of indication at the lever provided as that arranged with the other levers in the same system. Of course the normal position of the lever will lock

the switch and the reverse position will unlock it. Hence, the indication for the corresponding position of the lever and the switch should be reverse of that of a signal lever indication.

COMMUNICATING DEVICES. In connection with outlying switch locking, some means of communication must be maintained between the switch and the tower from which it is controlled. Bells and a bell code are often employed for this purpose, the circuit being arranged as shown in Fig. 201 by the means of one

FIG. 201.

wire. A hand switch located at the switch and one in the tower will, when either is depressed, ring the bell at the opposite end. This method of arranging a bell circuit is often installed between adjacent towers. A telephone used as a communicating medium will be found much more satisfactory for the use of trainmen, as it is frequently necessary to hold a conversation totally beyond the capacity of a bell code. With a telephone attachment a condenser is generally employed. As an alternating current is used, this permits condensers to be inserted without interfering with the operation of the circuits. Hence a direct current common or an operating wire used in the operation or indication of a switch locking circuit can also be used for a telephone circuit. An arrangement of this kind is shown in Fig. 202, in which, as is usually the case, a ground return is

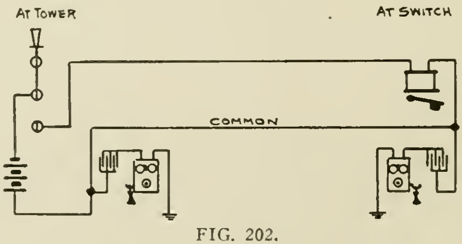


FIG. 202.

used for the telephone. It will be noted that on account of the condenser no direct current can pass from the lock circuit to the ground.

XII

BRIDGE LOCKING

GENERAL. Bridge locking is that class of electric locking where draw-bridges or other types of movable bridges are locked in their closed position, and so interlocked with the signals approaching the bridge that they cannot be cleared unless the bridge is locked in its properly closed position. This can be accomplished in various ways, and should not only include the interlocking of such levers in the interlocking machine as directly or indirectly control the bridge and signals protecting the bridge, but also provide the locking of other parts of the bridge, the proper position of which is important to the safe passing of trains. Hence, bridge locks, rail locks, bridge circuit controllers, bridge couplers and other appliances are necessary adjuncts to insure the safety of train movements over a drawbridge.

One of the most important factors of drawbridge locking is the provisions that must be made to prevent any attempt to put in motion the movable parts of a bridge unless all derails and signals protecting the bridge are in their normal position. Provisions for the locking of the drawbridge are not sufficient, as the bridge operator may start his machinery and injure the bridge operating parts, because the bridge, being locked, cannot move; or it may result in the breaking of the bridge-locking parts and cause the opening of the draw. The means and schemes employed in preventing the operation of a bridge when it is locked and in locking the bridge after it is unlocked will depend very much upon the type of control and manner of operation of the bridge.

BRIDGE ENGINE CONTROL. Where a bridge is operated by a steam or gasoline engine some mechanical means are generally provided to prevent the starting of the bridge operating machinery. This is generally accomplished by employing a lever in the interlocking machine to lock the engine which puts the movable parts of the drawbridge into motion so that it cannot be started when the lever is reversed. By having this lever operate an ordinary bolt lock or a facing point lock, which is connected to the lever of the engine, the engine will be under the direct control of what is generally called the "starting" or "bridge-lock lever" in the interlocking machine. By having all other levers in the

machine lock this lever reversed, either directly or indirectly, no other lever can be reversed until the engine is cut out, and the engine cannot be started again until all levers are normal. The engine-operating lever can of course also be locked electrically by an electric lock, preventing its release unless energized. It is desirable to also have the bridge itself locked in position by mechanical bridge locks operated from the interlocking machine.

Bridge Motor Control. When the bridges are electrically operated the electrical control wires may be broken through the starting lever or the bridge lock lever when normal, so that with this lever reversed the bridge operator will be unable to start the bridge machinery. It may also be accomplished by means of a relay so controlled that when the bridge is unlocked it will become energized, and the bridge control circuit broken through this relay.

Special Devices. Draw and lift bridge protection necessitates the use of various special devices to insure the correct position of the draw span and the rails, and to insure the completion of circuits and pipe lines over the bridge. Among these are bridge locks, rail locks, bridge circuit controllers and bridge couplers.

Bridge Locks. There are numerous devices and methods used for the purpose of locking a draw or lift bridge in its closed position. Many of these devices are specially designed for the particular type of bridge to which they are to be applied. All bridge-locking appliances should be designed to lock the bridge only when the draw is in the proper position, both with respect to its vertical and horizontal alignment.

With the so-called gravity bridge lock, the bridge is locked by a plunger which passes through holes in two castings, one of which is attached to the bridge and the other to the bridge abutment. The locking of a bridge can also be accomplished with a bolt lock, designed on the same principle as an ordinary bolt lock. The tappet which corresponds with the lock bar on an ordinary bolt lock is moved by the bridge-operating lever and locked by the plunger, which is operated from the interlocking tower. An F. P. L. attached to the bridge shoe is occasionally

used. Often, in conjunction with a bridge lock, circuit controllers are attached to the structure, which closes a circuit when the draw is in its proper position. In addition thereto, another circuit controller, which insures the proper position of the wedges supporting the draw ends, will close a circuit and a lever lock on the bridge lock lever controlled in series through these controllers.

Rail Locks. The lifting or spreading rails at the ends of draw and lift bridges must be locked to insure their being properly located for a train movement. A locking device of this nature must be applied to all rails to insure each rail being in position and properly placed before a signal can be cleared for train movements over the bridge. The rail ends of a drawbridge are often treated as switches and locked with F. P. L.'s of a design and construction much heavier than those used for switches. Locking cams and slide bars are used to a great extent for the proper alignment of the rails. Where locking cams are employed rail dogs are actuated by the rails when they assume their proper place and are locked by cams operated from the interlocking machine. Slide bar arrangements are on the same order as F. P. L.'s.

Bridge Circuit Controllers. Where it is necessary to carry circuits onto or across drawbridges, bridge circuit controllers are employed to disconnect the circuits when the draw is open and again connect them when the draw is closed. The circuit controllers are operated by mechanical connections and generally attached to some other bridge-operating or bridge-locking parts, such as the rail or bridge lock. As a rule, the track circuit is connected through the circuit controllers, thereby de-energizing the track relay when the draw is open. Other circuits, which it is desirable to break when the draw is open, can be carried through these controllers. The contacts are constructed and arranged so as to provide for considerable lateral and vertical misalignment and end play of the bridge with the fixed abutments or shore.

Bridge Coupler. A bridge coupler is a device used for connecting or disconnecting the pipe runs between the approach

and swing spans of a drawbridge where the continuity of the pipe runs is broken when the bridge is opened. The coupler consists of two sections, one of which is placed on the draw span, while the other is placed on the approach side.

INTERLOCKING ARRANGEMENT. The movement of trains over draw or lift bridges is generally protected by signals operated from one interlocking machine. Fig. 203 shows a typical draw-

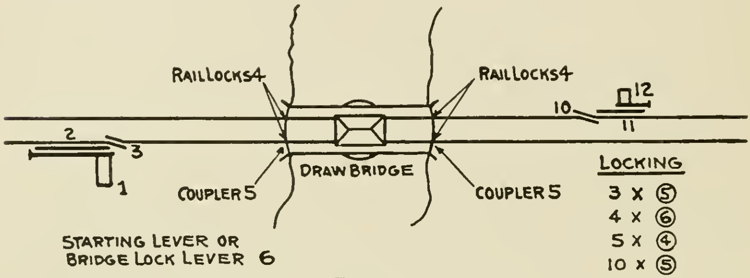


FIG. 203.

bridge layout for a mechanical interlocking. It will be noted that in addition to the levers required for the derail, F. P. L. and signals, a rail lock and coupler lever is employed. Furthermore, one lever is functioned as a starting or bridge-locking lever to lock and unlock the bridge operating machinery. Levers so functioned are interlocked with the operating mechanism of the drawbridge, making it impossible to operate the draw until it is placed normal. The bridge-locking lever when normal will permit the draw to be opened, but the lever cannot again be reversed until the draw is closed. Hence, in a layout, as shown in Fig. 203, the restoration to normal of lever 6 will directly or indirectly lock all derails in their normal position. Consequently, before the draw can be opened, all derails must be locked in a position to derail approaching trains that do not observe the signal indications.

At mechanical interlockings installed for the protection of a drawbridge it is always most desirable to operate the facing point locks and derails on each side of the tower with a separate lever as this will insure easier and safer operation and maintenance. It is also desirable, in most cases, to operate the couplers and rail locks at each end of the draw with separate levers. This is particularly true where the tower is not located on the draw-

bridge. Separate levers for the couplers will be necessary because the pipe lines at the tower end of the draw should be coupled before a through connection can be obtained to operate the coupler at the other end of the draw. Furthermore, it is desirable to lock the rails at one end of the draw before the connections are coupled, and to accomplish this the rail locks must be operated from separate levers.

At some interlocking plants the arrangement is as shown in Fig. 204. Here rail locks and bridge locks only are used, the

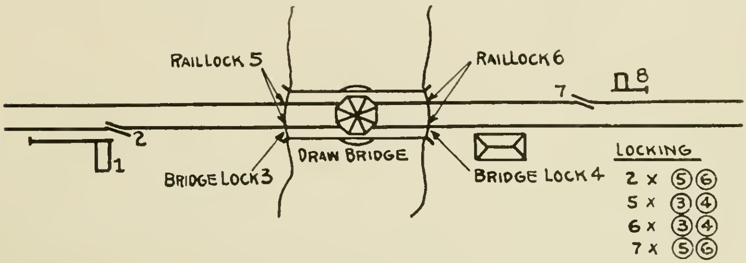


FIG. 204.

bridge locks being applied to the bridge proper and the bridge-operating protection provided by electrical means. The interlocking will insure that, before the bridge is unlocked, the derails must be normal and the rail locks withdrawn. Conversely, the rail locks cannot be reversed until the bridge is locked, and the derails cannot be reversed until the rails are properly locked.

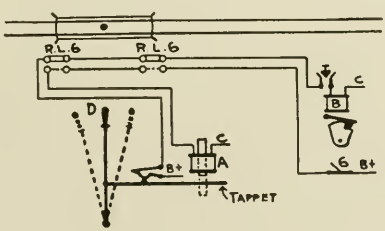


FIG. 205.

Circuit Arrangements. An electric arrangement of locking an engine lever, where the interlocking is located on the shore end and the bridge-operating room on the bridge, is shown in Fig. 205. When starting lever 6 normal plunger lock A, which locks tappet bar attached to lever controlling throttle of bridge engine D, will

be energized. An indication lock B on lever 6 will release this lever only when the engine-controlling lever is normal and the rail lock in the proper position. Fig. 206 illustrates another

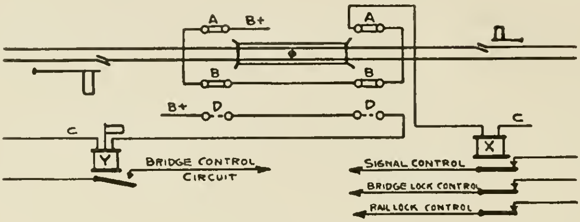


FIG. 206.

method, in which circuit controller A closes automatically only when the draw is in proper position and B closes automatically when the wedges supporting the draw ends are in the proper position. This will energize relay X, which controls the signals, bridge and rail locks. Circuit controller D closes when the bridge and rail locks are withdrawn by these levers being placed normal and this circuit will energize indicator Y in the bridge-operating room and complete the bridge control circuit.

One scheme of an electrical locking arrangement of a complete drawbridge protection is shown in Fig. 207. It will be observed

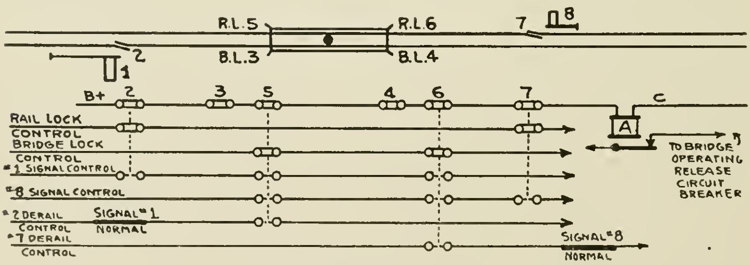


FIG. 207.

that the bridge operating release circuit breaker is controlled through relay A and this relay can only be energized by the normal position of all derails, bridge and rail locks. In order to clear a signal the circuits are so arranged that this can only be accomplished by the locking of all devices in proper sequence. The arrangement insures that the derails cannot be reversed and the signals cleared unless the rail locks are reversed. The unlocking of the bridge can only take effect by the rail locks being placed

normal; this can only be done if the derails are normal, and the bridge lock can only be placed normal after the rail locks are normal. The derails are equipped with normal and reverse locks, which are controlled through the track circuits and, if desired, through route-locking mediums. As the opening of the draw will de-energize the track relays, the derails will be locked in their normal position as an additional protection against their reversal during the operation of the bridge.

Another scheme of bridge-locking protection is shown in Fig. 208. Here relay A is controlled through normal contacts on the

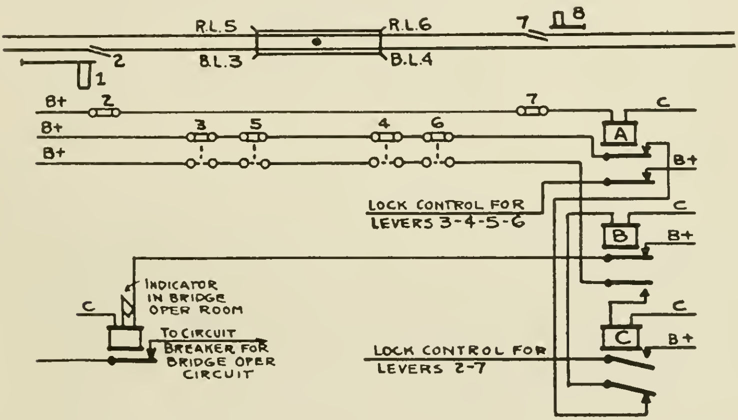


FIG. 208.

derails and the rail and bridge locks controlled through a front point. Relay B is controlled through normally closed contacts, the bridge and rail locks when these are normal, and through a front point of relay A and a back point of relay C. This relay controls an indicator in the bridge-operating room (generally provided where the bridge-operating room is located away from the interlocking tower) and the indicator controls the bridge-operating circuit breaker. Relay C is controlled through reverse contacts on the rail and bridge locks, and a back point of relay B. This relay controls the operation of derails 2 and 7. In this way a complete indication as to the proper position and operation of all devices is procured, thereby insuring a mechanical as well as electrical interlocking of all apparatus used in the protection of trains for movements over the bridge. At power interlockings where all bridge and rail locking is operated by switch or dwarf

mechanism additional protection is provided by the indication that is given by such mechanisms to insure a corresponding position of the function and the lever by which it is controlled. Circuit arrangements can also be made where two individual bridge locks for each bridge are provided, one controlled from the interlocking machine and the other from the bridge-operating room, when the bridge-operating room bridge-lock is controlled through contacts on the interlocking bridge lock as shown in Fig. 209. Hence the

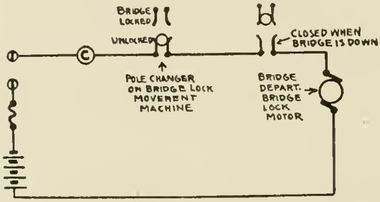


FIG. 209.

bridge cannot be unlocked until a release is obtained from the leverman in the tower by his operation of the interlocking bridge lock lever.

Arrangements are also in use where contacts on the bridge lock lever in the interlocking machine, when this lever is normal, will complete the bridge operating circuit.

TRACK CIRCUIT. At draw or lift bridges, where track circuits are employed for electric locking or other purposes, it is always desirable to continue these through the rails across the bridge so that no dead section will be present in the track circuit protection. The rails across the bridge can be cut out of the track circuit. Submarine cables are often employed to complete the track circuit between both drawbridge abutments, but this is not advisable as submarine cables are not only very costly, but such an arrangement does not break the track circuit when the bridge is open, nor does it give proper track circuit protection against broken rails, etc. A circuit breaking device operated coincidently with the movement of the bridge is an advisable feature to employ. Hence the most general and safest way of arranging a drawbridge track circuit is to maintain a circuit through the rails of the bridge by means of two or more bridge circuit controllers. These controllers are either operated by the same lever that moves

the bridge-lock which locks the bridge in its closed position, or the lever operating the rail-locks which locks the rails in their proper alignment, the arrangement depending upon the scheme of electric locking protection. They can also be operated by a separate lever which can be moved only after the bridge is set and locked in its normal position. At mechanical interlockings they can be operated in conjunction with the pipe coupler, which couples and uncouples the pipe lines extending over the bridge.

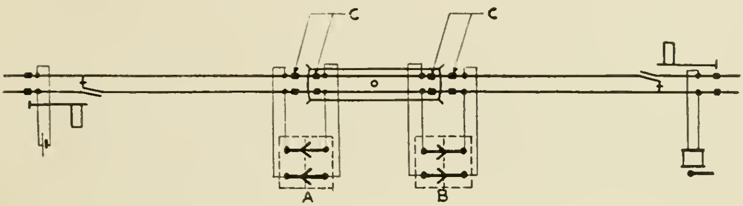


FIG. 210.

Fig 210 shows a track circuit carried across a drawbridge by means of two bridge circuit controllers A and B. It will be noted that insulated joints C are placed in each rail at both ends of the bridge and at the end of the pier tracks. While this is not always necessary it is a very commendable practice as it will tend to simplify the insulating of other parts of the bridge, which may often become quite complicated. Jumpers from each rail are connected to the respective sides of the bridge circuit controllers, half of each controller being located on the piers and half on the bridge. At places where no continuous track circuit can be maintained the installation of a trap circuit arrangement is recommended. There are drawbridges, however, where no track circuit can be maintained, due to the employment of steel ties or bridges which, being built of steel, are constructed so as to receive the rails without the intervening wooden ties. In such cases there is no alternative but to leave the bridge a dead section by placing insulated joints at each end of the piers and joint the rails with jumpers placed in a submarine cable. In this way the entire bridge will constitute a dead section. The installation, therefore, of some type of a trap circuit is to be recommended.

XIII

TESTING

General. There are a number of very essential tests that should be conducted both before and after an electric locking protection is put in service at an interlocking plant. The indication magnets, lever locks, relays and other magnetic safety appliances should be checked out to determine the pick-up and drop-away values, resistance of coils and contact resistance of all points. This should be done before the electric locking is placed into operation or actual service, since it is more convenient to do so at such a time, and allows changing out any defective parts or units without interfering with the operation of the plant. Tests to ascertain the safe service conditions of the circuits and appliances should, of course, be conducted at frequent intervals.

INSTALLATION TESTS.

Method. After the electric locking is installed tests should be made to insure the circuits and apparatus being properly designed, applied and installed. These tests should be made before a system is approved and put in service. With such tests it is not only necessary that the installation be checked to correspond with the circuit plans, but a thorough test should be made to make sure that the desired protection has been fully accomplished. A complete knowledge of the principles of the electric locking scheme employed is essential to the satisfactory testing of a plant, and when testing the circuits conditions should be as near a duplicate of the regular operation of a circuit during actual service as circumstances permit.

A good method of testing electric locking installations is to first compile a chart in which all routing of trains is taken care of by the levers being manipulated in proper sequence and in accordance with the interlocking in the machine. This method is desirable because it is difficult to thoroughly check the electric locking for a complicated track layout by the interlocking plan. It is insufficient to conduct a test by trying out the circuit plan, as errors in the design and construction can only be found by a thorough test duplicating the ordinary service conditions.

Wiring. It is required, before placing wiring in service, that the wiring of each circuit be tested for crosses, grounds and continuity of the circuit. For this purpose a megger or magneto is generally employed. The testing is done by disconnecting the wires at each end of the circuit and connecting the testing instrument between the wire and ground. Where a common return wire is employed it is also desirable that the common wire be tested for grounds unless local conditions make it impossible to keep this wire entirely free from grounds. Tests should also be conducted by connecting the testing instrument between all wires of circuits with which it is possible for the circuit being tested to be crossed, and also ring out each complete circuit to ascertain its continuity. A detailed check of all wires should be made to verify the marking of the tags with the plans and to determine whether the specification for the installation has been complied with.

Relays and Indicators. A test of all relays and tower indicators should be made to see that the RailwaySignal Association's specifications for the pick-up, drop-away, contact opening and armature air gaps are complied with. If the coils of a relay or indicator are changed to a slightly higher or lower resistance, the pick-up and drop-away values will frequently change beyond the required limits, in which case the armature drop-away or pick-up air gap must be changed until the correct value of the points is reached and the specifications met. If the contact finger opening of the relay is changed, enough spring tension must be left on the fingers to secure sliding contact when the coils are energized. The pick-up and release test of indication magnet coils is conducted in the same manner as the relays. When taking the pick-up of these magnets, on most types of power interlockings, only the first reading should be considered, and if another reading is necessary the lever should be operated before any is again taken. This is necessary because of the mechanical construction of the indication parts on the lever, which will remain in a released position after once being actuated.

Track Circuits. Track relays are checked by shunting each respective track section to determine whether the relay responds properly. Track repeaters or track indicators are checked by

shunting the track section or by directly dropping the track relays to determine whether the repeater relay or indicator duplicates the movements of the track relay. All track and fouling circuits and frog bonding should be checked. A test with a voltmeter will greatly simplify this procedure, and all fouling circuit readings should be taken back of the clearance of the diverging route.

LEVER LOCKS. Notches cut in the levers of a power interlocking machine for the receipt of the plungers or locking dog must be tested for proper clearance. The lever must first be tested for clearance for every combination that locks it. This is accomplished by having the lever in question locked by another lever through the medium of the mechanical dog locking. Then the lever is pulled or pushed hard in either direction to take up all lost motion, current being applied to the lock during this operation. After all lost motion is taken up and after current is cut off from the lever lock it should be noted whether the lock plunger or dog rests into the notch in the lever or whether it rests on top of the lever. If the maintainer is unable to observe the position of the lock plunger, the mechanical locking holding the lever under test should be released and an attempt made to manipulate the lever without the lever lock being energized. If this can be done it shows that the locking plunger did not drop into the notch in the lever and, consequently, the notch must be cut out further to give proper clearance. Generally a ⅛-inch clearance between the locking plunger and the edges of the notch in the lever, with the lever in the locked position, is required for the safe operation of the lock. Repeat the test for other locked positions of the lever and for every combination that locks it.

On mechanical interlocking machines the notches cut in the locking segments of the lever lock for the receipt of the plunger or dog on the electric locks must be tested for clearance. This is done as described with power interlockings, by having the lever in question locked with another lever through the medium of the mechanical dog locking and then raising the latch handle as far as possible, thus taking up all lost motion. After this is done, observe the position of the locking dog, or test to see whether the lever will unlock with the lever lock de-energized. Also make tests to ascertain whether the lever lock takes effect with the

lever in the proper position. To conduct such a test the proper line-up of levers should be made to insure the lever in question being released by the mechanical locking. The lever should then be operated with current cut off from the lever lock and notice taken of the travel permitted the lever or the lever latch with the lever lock de-energized. If, for instance, the latch on a mechanical interlocking machine can be operated more than one-quarter its stroke from the latched to the unlatched position, or from the unlatched to the latched position (depending, of course, upon when the lever lock is to be effective) the lost motion effecting this should be removed. If levers on power interlockings can be operated more than the thickness of the plunger lock or locking dog further than specified, the lost motion by which it is effected must be removed. Also make tests to certify all current being cut off the lever locks when the lever is fully normal and reverse.

Indication Locking. In indication locking the levers should be tested for lost motion in mechanical connections as well as for indication lock adjustment. On switch levers first remove the fuse so that the function controlled will not operate. Then reverse the lever, noting whether it stops in the indicating position, after which proceed to pick the indication and move the lever to the full reverse position. Repeat the operation while moving the lever normal. On some systems of interlocking it is necessary to have the switch reversed while testing the normal indication, and vice versa. On signal levers it is, of course, only necessary to test for normal movement of the lever. On other types of signals it is necessary to disconnect the indication wire at the lever in order to prevent an indication being received at the lever.

Where levers are given a twisting motion during the operation, make a test by quickly twisting the lever with considerable force so as to determine whether or not the indication latch will bound out of the slots or quadrant. When testing double switch levers test each one separately. Each test should be repeated four times and the levers operated as when handled by the leverman. After each lever test replace the wire or fuse and see that indication is properly received.

The next test will be to ascertain whether a function will indicate before it has assumed the proper position for the safe move-

ment of trains. This is done for switches by inserting a test gauge in the switch point and noting whether the switch will indicate on any gauge larger than that specified as standard by the road. This, of course, should be done with both positions of the switch.

For signals conduct test by clearing the signal and noting at what angle from the horizontal position of the semaphore arm it will indicate. This can readily be done by attempting to put the lever full normal while the arm is at various positions and moving toward the horizontal position. Another method is to insert an ammeter in series with the indication circuit and observing at what angle of the signal arm the needle is deflected.

Test indicators on 3 pos. signals to determine that a double indication is not received while the signal goes from the 90 to the 0-deg. position. It should be impossible to release the lever when the signal reaches the 45-deg. position, as the signal might stick clear in this position and an indication received.

Section Locking. Test section locking by setting up routes for the various train movements and have a man shunt the different track sections within the interlocking limits while the levers, locked by these track relays, are tried to detemine whether they are locked in their proper position. If the track indicator or track relay becomes de-energized while the shunt is on the track and it is impossible to release the levers that should be locked, the section locking is in proper order. If it is possible to move the locked lever, the lever lock may be out of adjustment or the indicator or track relay out of order, and readjustment should be made immediately, after which the test is repeated.

At power interlockings where section locking is effective by breaking the positive control wire for the switches, the observation of whether or not the switch takes current by watching the ammeter is sufficient. If no ammeter is provided the switch must be watched on the ground. Test all lever selections and combinations of the section locking scheme so as to see if contacts are broken at the proper time and that proper contact shunts are provided as called for. The facilities made for parallel train movements is a particularly important feature.

Route Locking. Route locking is tested by setting up all possible routes at a plant and observing, by trying the locked levers, whether they are properly locked. Then create conditions similar to those existing when a train is actually passing over the route, and note whether all levers equipped with locks are retained in the locked position until the train is on the release section or track instrument, or passed out of these. All possible conditions that the installation of the route locking is intended to obviate should be tested. For example, if the route locking should not be released unless the signal is placed normal while the train is occupying the route, this should be tested. It should be evident that route locking must be tested for opposing train movements on all routes.

While a route is locked up it is also desirable to try all levers that should not be locked to make certain that errors in the circuits have not been made which will tie up parallel lining-up of routes.

Stick Locking. In stick locking installations, test the locking by first setting up the routes to which the scheme has been applied. Where the stick locking takes effect with the clearing of the signal arm only, reverse the signal lever and clear the signal to about 5 deg. from the horizontal and then quickly place the lever normal. This is done to insure that the locking is effective with only a partial clearing of the signal and to prevent the release of the locking unless the signal has assumed the stop position. After it is ascertained that the locking has taken effect by noting the position of the stick relay and trying the locked levers, effect the release as with a regular train movement. If the locking is effective with the reversal of the signal lever, pull this lever far enough to break the cross-protection contact on the normal contact of the lever; or, if a mechanical signal, just raise the latch and the locking should then take effect. The circuit should be arranged to take effect with only a partial reversal of the lever in order to prevent the stick locking from failing to take effect if a signal should partly clear as soon as the cross-protection contact is broken, which might be caused by a cross on the control wire. Next test the levers and release the locking, as previously discussed. If the stick locking breaks through two signal circuit controllers in series and if only one is controlled

from a lever contact as, for instance, a home and a distant signal, clear the home signal as described. The distant signal will not clear because the home signal has only partly moved from the normal position. This will check the home signal circuit breaker.

Then take a jumper and shunt around the home signal circuit breaker; clear the home signal, which will also clear the distant signal, and, if the stick locking takes effect, it is a sure sign that the locking is also controlled by the distant signal. Another method is to move the distant arm to clear by hand while home signal is at danger. Where many levers in series control the stick locking, reverse each lever successively and note whether the locking takes effect with each lever reversal.

Approach Locking. First test the approach indicator to see that it indicates the approach of a train when the train is at the proper distance from the tower or the home signal. Then set up the routes to which approach locking is applied and observe, by dropping the approach indicator, whether the locking is effective with this indicating the approach of a train. Also ascertain by test that the locking does not take effect if no train is approaching. Then try the locked levers and release the locking in the same manner as when a train passes over the route.

Sectional Route Locking. In sectional route locking line up the complete routes for train movements and with the signal at clear try all levers to see whether they are properly locked. Then drop all track relays in successive order and try if all levers controlling the switches and derails ahead of the train are locked up and if all the switches in the section just passed by the train are released. Tests should be conducted for every possible combination of movements and routes which can be set up for trains. Try the levers that should not be locked by the route locking of one route to see that non-conflicting line-up of routes can be made.

Check Locking. In check locking one man at each tower between which the protection is applied should be in constant communication with another. Test the locking by arranging the locking and unlocking of the protection as with regular train movements. While the locking is in effect all track sections which will affect the check locking between the towers should be

shunted and circuit controllers on signals, if they also control the locking, should be tested to insure the complete protection being provided.

Emergency Releases. In all types of locking it is evident that, where emergency releases or other methods of releasing are employed, they should be reversed or actuated in order to determine whether this part of the circuit is in correct working order. While the release is reversed also try such levers or apparatus that should be locked during the operation of the release. Always note that it takes the specified length of time to actuate the release, as this is of much importance.

Time Locks. Mechanical time locks attached to an interlocking machine should be tested to see that they release after the specified time lapse; and also that the mechanical locking, if such is connected with them, is performing its function properly. Hand operated time locks should be manipulated and tested for correct time operation.

Screw Releases. Test for the shortest possible time required to operate them. Note whether, as soon as the release is started from its normal position, the circuits controlled through the normal contacts are broken and also that the reverse contacts are not made until a complete reversal of the release has taken place.

Annunciators. Test annunciators by shunting the track section by which they are actuated. Also note whether cut-out switches or other circuit arrangements provided for the cutting out of the annunciator have the proper effect.

Outlying Switch Locking. Test the lock at the switch to see if it can be unlocked without a release from the tower. The lock in the tower should be tested to see if it can be released before the switch is completely locked. Where switch point protection is also provided, test to find out whether the lock in the tower will release with a point gauge inserted in the switch point.

Bridge Locking. Test all apparatus and circuits to see that they take effect and accomplish their purpose at the proper time and in a correct manner.

SERVICE TESTS

In addition to installation tests as just described, it is necessary to conduct service tests at frequent intervals to ascertain that the apparatus and circuits continue to give the protection and perform the function for which they were installed. These tests are conducted along the same lines as the previously described installation tests, although in many cases it is not necessary to make them as rigid and thorough. It should be observed during such tests that no tests or adjustments which might cause detentions to train movements should be made until information has been received relative to approaching trains. The handling of levers during tests should be done by the lever-man or under his direct supervision, so that he will know at all times the position of the levers. As an example on the frequency of such tests it can be stated that lever locks should be tested once a week to see that they take effect properly. This is generally done by operating the locks while noting that the plunger or lock dog pick-up and drop in correspondence with the closing and opening of the circuit through the lock coils. A monthly test is made to ascertain the proper clearance of notches and to discover badly worn parts, which may be the cause of dangerous derangements. Other tests are either conducted semi-yearly or yearly, as conditions warrant.

XIV

MAINTENANCE

General. A proper and systematic method of maintenance depends, in regard to details, upon existing conditions to which the particular system is subjected. Each system or installation may have its weak places so that a discussion of maintenance can be carried on only in a general way. Where circuits and devices are in service for electric locking purposes it is of utmost importance that they should perform their work and operate in accordance with the purpose of and the plans used in the installation. It is generally known that levermen, accustomed to the check and restrictions imposed upon them by the employment of electric locking, will grow careless and depend principally upon the devices and locking provided for the safe handling of interlocking apparatus and traffic. The average leverman, for instance, would, if he could contrive to do so, change a route without first manipulating the hand screw release and probably compliment himself on his adroitness. In all probability he would forget or perhaps deliberately neglect to notify the maintainer that the screw release was out of order. It might be said of any type and scheme of electric locking or, for that matter, of any scheme of signaling, that the system is as safe as its maintenance. All appliances and circuits must be efficiently maintained so as to continue to give the safe service that its installation intended. Hence failures occurring with the electric locking which tend to create dangerous conditions should be a cause for severe discipline and unless the maintainer has redeeming qualities his services should be dispensed with.

Safety Precautions. It is of first importance that electric locking appliances be protected from any tampering or any operation which tends to beat the combination. Such an operation might happen through deliberate action on the part of the leverman or some one present in the tower. Deliberate or accidental action to this effect can only be prevented by adequately keeping under lock all devices that should not be accessible to the leverman or others. If this is not done there are no restrictions placed on the leverman and the electric locking may be circumvented without a check being had upon such action. For this reason all com-

partments, interlocking machine cabinets and cases enclosing circuit controllers, releases, indicators, relays, etc., should be properly locked at all times. Nevertheless, it is necessary to do something in case of a derangement of apparatus, otherwise it would be impossible to change a route, with consequent congestion and delay to traffic. Some railroads equip all devices to be locked up with padlocks and provide a key box containing the key for the unlocking of such apparatus or interlocking machine parts which, in an emergency, the leverman should have access to. Such boxes are equipped with a glass front which must be broken before the key can be obtained. The leverman is kept accountable for such breakage and must record on the daily report blank the occasion for such action. The key box should be so constructed that the glass can readily be replaced and the maintainer must do so at the earliest opportunity. Glass pieces should be kept on hand for this purpose. On some railroads devices, instead of being locked, are sealed with a car seal or similar article. Then if there is real need of getting access to the sealed part the leverman can break the seal, open the case and, for example, "pick" a lock. It is obvious that sealing irons, seals, etc., must only be in possession of one responsible person and not the leverman. In this way a check is maintained, as in the case of the glass front box or broken seal, since such a procedure must be recorded. It should be noted at least every morning and night that the seals or glass are intact. In case the leverman fails to report the necessity of breaking into the apparatus, when getting the box in order again it should be noted that all apparatus is properly locked or sealed.

Failure Emergency Instructions. In case of failure of the electric locking, when, for instance, it fails to release after a train has passed out of the limits of the locking section, the leverman should operate the emergency release or the hand screw release. If this has no effect, note whether all levers, signal arms or any apparatus that will affect the electric locking are in their proper positions, after which again actuate the release medium. If this fails to release the electric locking the maintainer should immediately be notified. If it is necessary to operate any of the locked levers before the maintainer arrives many railroads, in order to save train delays, permit the leverman to release the

lock by hand. This can only be accomplished, however, after the leverman has gained access to the key which unlocks the lever lock, by breaking the glass of the key box or by breaking the seal placed on the lock. Before unlocking the lever lock by hand the leverman is required and held strictly accountable for the proper position of the derail, switch signals or any other signal appliance whose lever is electrically locked. He should ascertain that the track within the limits of the locking section is unobstructed and that no car is standing within the fouling limits of the track circuit. When all this has been attended to the lever may be operated. With regard to outlying switch locking and bridge locking, failures of lever locks or tower instruments should be reported to the maintainer immediately and under no circumstances should the leverman operate or be given a chance to operate such locks in any other than the regular manner.

Inspection. The most careful inspection and frequent service tests of electric locking are highly justified, as a careless, excitable leverman may cause serious trouble during a derangement. It should particularly be forcibly impressed upon all maintainers that a regular inspection as well as testing of all lever locks is imperative to the safe operation of a plant. Always note that they are properly locked and sealed; that all openings are closed, allowing no possible chance for the leverman to "pick" the lock and thereby circumvent the electric locking. Also observe that the lock is securely fastened to its support and the support rigidly attached to the machine. Note that cotters or seals on pins of connecting rods to electric locks on mechanical interlockings are in place and intact; that the covers are properly on and locked. On lever circuit controllers see that the contact bands and strips are in the proper place; that they are not loose or have slipped out of their notches, and that all terminals are tight.

During inspection take cognizance of all other apparatus connected with the electric locking; give attention to the relays, terminal boards, arresters, etc., and have loose nuts, screws and posts tightened. Inspect time locks and screw releases, etc., noting that all pins, cotters, bolts and nuts are in place. Also examine batteries to see if exhausted or in need of charging. Observe the operation of track relays, track repeaters, indicators and annunciators during the passing of trains and note whether they operate

quickly and properly. Where "SS" relays or indicators are employed, observe that they open and respond as the switches change their positions. Make tests to ascertain the effectiveness of the electric locking protection, such as approach locking or stick locking of signals and advance, route or section locking of switches. Actuate emergency release mediums and particularly note whether breaking the normal contacts has the proper effect upon the signal control circuit or other circuits. On tower indicators note that glass is not broken and that they are properly locked. Indicators having no contacts for the control of circuits need not be locked as any improper operation will be of no consequence to the safety of the plant. Emergency switches should be examined to make sure that they are placed in their proper position and that the glass covers are in good condition.

Lever Locks. Lever locks and particularly solenoid plunger lever locks should be thoroughly cleaned four times each year. During such cleaning all gummed substance and dirt must be thoroughly wiped away and removed from all movable parts and journals so that there will be no possibility of dirt or other foreign substance preventing the lock from dropping by gravity. On solenoid locks the plunger and brass tube inside the solenoid should be cleaned in a similar manner with a dry cloth. On all electric locks, and lever locks in particular, it is of utmost importance that the lock dog, plunger and notches in the lever or in the lock segment have perfectly square edges, so that there will be no possible chance for the lock to become ineffective and cause a dangerous derangement of the electric locking. When recutting or enlarging the notches in levers or locking dogs for lever locks, always see that the corners are left square and the surface that comes up against the lock plunger or dog vertical, thus avoiding a tendency to force the lock plunger out by pulling hard on the lever. Each lever lock should be tested by putting on and taking off current several times to ascertain whether it works properly, in which case its operation should be quick and sharp.

When enlarging a notch in a lever lock, it should be done by chipping with a light hammer and small cape chisel, being careful to prevent the chips of iron from getting into other parts of the machine or locks.

When the cover on lever locks for mechanical interlockings is in place, the locking dog and connecting rod to it are completely covered, which prevents any tampering with them. To assist in this connection a shield is generally secured to the lock bracket to prevent a wire or tool from raising the locking key if thrust into the hole through which the connecting rod extends. Care should be used when replacing covers on lever locks and circuit controllers, as the space provided for wires is very limited. If it should happen that the cover rests upon an insulated wire it will result in the insulation wearing off and cause a ground.

Lever Indicating Parts. At interlockings where the lever indicating parts are not visible it should be a general practice to remove the levers from the machine once a year, together with all of the indicating parts, pins, studs, dogs, springs and latches, all of which are carefully inspected and worn or broken parts replaced. It is particularly important that all sharp edges on dogs or other parts are not worn round or changed in shape or size.

In testing it is advisable to proceed as follows: Select a lever and guide that is in good condition and, with new indicating parts, mount them upon a stand so that the lever can be manipulated the same as in the machine. Test the lever by manipulation and actuate the indication or safety magnet after the lever has come to a stop. These magnets should not operate on less than the minimum allowable current. Any coil not up to standard requirements should be renewed. Not only is the safe condition of the indicating parts necessary, but all parts must move freely while the lever is operated. Where a considerable number of interlockings of one type are to be tested on one road the most efficient method is to commence at one plant and place new indication dogs, latches and other such parts, whether worn or not, in one machine; then make a careful inspection of the ones removed, using only those in good condition at the next plant.

General Maintenance. Contact springs and commutator springs must be kept clean at all times.

Bells and buzzers employed as annunciators in towers are generally sheltered from the weather. The only thing liable to interfere with their proper operation is dust and dirt between the contact points. Naturally, a burnt out coil or broken spring

appears occasionally. On single stroke bells note that the armature stops hold the hammer clear of the gong when the armature is attracted so as not to deaden the sound.

Bridge circuit controller contacts in particular should receive frequent attention on account of their exposure. They must be cleaned every day in winter because they quickly become frosted, owing to improper covering. On damp days the plungers become coated with moisture, necessitating frequent wiping, so as to prevent high contact resistance, which will make track circuit operation difficult. Wire leads and terminal parts should be watched closely on bridge circuit controllers as they often break and jar loose on account of the excessive vibration to which drawbridges are subjected. Wires are also susceptible to ground at such places, caused by the insulation rubbing against the iron work. Outlying switch locks are subjected to much rough handling by train crews, who may become impatient while waiting for a switch release. They should receive frequent inspection.

Renew the oil in the cylinder on liquid time releases twice a year by refilling with thin, non-freezing oil.

Contacts exposed to the weather, such as switch box contacts or contacts on the signals, must be inspected more frequently than other contacts. The gaskets on the covers of such circuit controllers should be in good condition so as to have the contacts protected from the weather.

Failures. Improper manipulation of emergency and screw releases by the leverman results in many failures and causes the maintainer a great deal of trouble. With screw releases, for example, they effect the release by reversing it, but fail to place it normal again, perhaps because at that particular moment the signal which breaks through the normal contact is not to be cleared; or perhaps because, while the leverman worked the release, he was interrupted by the dispatcher and forgot about the release until a train startd to whistle for a signal. Hence, in many cases the release may be left half way over, which will prevent the clearing of the signal and necessitate calling out the maintainer to locate the suspected trouble. For this reason, where electric locking is employed, many maintainers make it a practice to look at the screw releases first when they are called out for a failure. Contacts on cut-out keys for annunciators have also caused delays on

account of being bent or in a shape which prevented their making good contact. It is, therefore, important that they be inspected and cleaned frequently in order to insure the proper contact being made at all times.

In cases of failures always ascertain first whether it is a circuit failure or a failure of the apparatus; if a circuit failure, proceed to discover which circuit is affected. In many cases one failure may lead to another; but in all cases locate the basic cause of the failure and remedy it before attempting to locate other derangements of the deranged circuits. As an example of how to proceed, a stick relay circuit failure will be taken for illustration. Failures on such circuits may happen by the stick relay failing to drop or pick up when it should. When testing for failures on a normally open stick relay circuit it is desirable to disconnect the stick circuit at the relay point and then conduct the tests in a regular manner.

When testing a normally closed stick relay circuit it is desirable to close the stick circuit by placing a temporary jumper around the relay stick contact and then conduct the test. As the stick relay occupies an important place in an electric locking circuit and changes as above suggested may create dangerous conditions, it is evident that even temporary alterations of this kind should be made only after all precautions have been taken to guard against any circumvention of the electric locking protection. It may often be desirable to have a man located at the relay to make the alterations only when the electric locking is not effective.

After a circuit has been disconnected, wires replaced, or the cause of the failure of a circuit remedied, its operation should be tested before again being placed in regular service. This can be done during the next train movement over the plant, but if none is likely to occur within a reasonable length of time, create a condition which will make a similar check possible. In all cases the test must be made as near a duplicate of the regular operation of the circuit as circumstances permit.

THE END